US008888824B2

(12) **United States Patent**
Austin et al.

(10) **Patent No.: US 8,888,824 B2**
(45) **Date of Patent: Nov. 18, 2014**

(54) **SYSTEMS AND METHODS FOR USING POLYAXIAL PLATES**

(71) Applicants: **Gene Edward Austin**, Bartlett, TN (US); **Jon A. Harmon**, Byhalia, MS (US); **Timothy J. Petteys**, Bartlett, TN (US); **Thomas A. Russell**, Collierville, TN (US); **Paul Tornetta**, Chestnut Hill, MA (US); **William M. Ricci**, Richmond Heights, MO (US)

(72) Inventors: **Gene Edward Austin**, Bartlett, TN (US); **Jon A. Harmon**, Byhalia, MS (US); **Timothy J. Petteys**, Bartlett, TN (US); **Thomas A. Russell**, Collierville, TN (US); **Paul Tornetta**, Chestnut Hill, MA (US); **William M. Ricci**, Richmond Heights, MO (US)

(73) Assignee: **Smith & Nephew, Inc.**, Memphis, TN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/774,721**

(22) Filed: **Feb. 22, 2013**

(65) **Prior Publication Data**

US 2013/0172943 A1 Jul. 4, 2013

Related U.S. Application Data

(63) Continuation of application No. 12/069,331, filed on Feb. 8, 2008, now Pat. No. 8,382,807, which is a continuation-in-part of application No. 11/996,795, filed as application No. PCT/US2006/028778 on Jul. 25, 2006.

(60) Provisional application No. 60/702,231, filed on Jul. 25, 2005.

(51) **Int. Cl.**

A61B 17/80	(2006.01)
A61B 17/74	(2006.01)
A61B 17/86	(2006.01)
A61B 17/00	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 17/8057*** (2013.01); ***A61B 17/74*** (2013.01); *A61B 17/8085* (2013.01); *A61B 17/863* (2013.01); ***A61B 17/8061*** (2013.01); *A61B 2017/00004* (2013.01); ***A61B 17/8605*** (2013.01)

USPC **606/289**; 606/293

(58) **Field of Classification Search**

USPC 606/289, 293

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

300,146 A 6/1884 Sinnett
351,751 A 11/1886 Douglas

(Continued)

FOREIGN PATENT DOCUMENTS

AU 754857 11/2002
CA 2047521 1/1992

(Continued)

OTHER PUBLICATIONS

Examiner's First Report on Australian Application No. 2006272646, mailed Mar. 21, 2011, 4 pages.

(Continued)

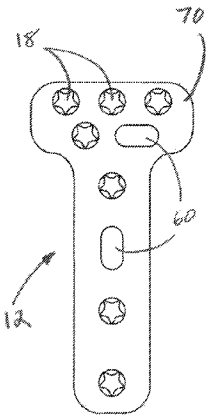
Primary Examiner — Andrew Yang

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

Certain embodiments of the invention provide plates for treating periarticular fractures or other non-full body weight bearing applications that combine polyaxial fixation with a low profile and enhanced contouring that more closely conforms to bone. Such plates can be designed to achieve buttressing effect and/or to be used in a reinforcement mode. Other features can be combined with these. Such plates can be created for use on bone sites such as on a tibia, fibula, metatarsal, calcaneous, other foot bone, humerus, radius, ulna, spinal, maxillofacial, as well as sites on other bones.

24 Claims, 46 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

382,670 A 5/1888 Trovillion
544,606 A 8/1895 Balsley
545,331 A 8/1895 Balsley
565,808 A 8/1896 Staples
575,631 A 1/1897 Brooks
583,158 A 5/1897 Upham
637,990 A 11/1899 Hoepner
651,949 A 6/1900 Lillie
689,722 A 12/1901 Hoover
766,270 A 8/1904 Lapham
775,427 A 11/1904 Lusted, Sr.
902,040 A 10/1908 Wyckoff
1,025,008 A 4/1912 Miner
1,105,105 A 7/1914 Sherman
1,275,810 A 8/1918 White
1,575,149 A 3/1926 Craig et al.
1,755,588 A 4/1930 Bronk
1,925,385 A 9/1933 Humes et al.
2,010,913 A 8/1935 Bruce et al.
2,133,859 A 10/1938 Hawley
2,152,977 A 4/1939 Shindel
2,388,921 A 11/1945 Kooiker
2,501,978 A 3/1950 Wickman
2,524,167 A 10/1950 Grande
2,560,912 A 7/1951 Aitto
2,667,194 A 1/1954 Fisher et al.
2,756,791 A 7/1956 Ferrara
3,056,441 A 10/1962 Helms
3,279,510 A 10/1966 Dreyer et al.
3,347,293 A 10/1967 Clark
3,409,058 A 11/1968 La Pointe
3,547,114 A 12/1970 Haboush
3,552,389 A 1/1971 Allgower et al.
3,630,261 A 12/1971 Gley
3,662,797 A 5/1972 Healis
3,668,972 A 6/1972 Allgower et al.
3,716,050 A 2/1973 Johnston
3,739,825 A 6/1973 Knox
3,741,205 A 6/1973 Markolf et al.
3,744,488 A 7/1973 Cox
3,779,240 A 12/1973 Kondo
3,782,432 A 1/1974 Allen
3,866,607 A 2/1975 Forsythe et al.
3,906,550 A 9/1975 Rostoker et al.
3,935,762 A 2/1976 Tudisco
RE28,841 E 6/1976 Allgower et al.
4,059,102 A 11/1977 Devas
4,060,114 A 11/1977 Matsushima
4,096,896 A 6/1978 Engel
4,219,015 A 8/1980 Steinemann
4,246,811 A 1/1981 Bondhus et al.
4,263,904 A 4/1981 Judet
4,338,926 A 7/1982 Kummer et al.
4,364,382 A 12/1982 Mennen
4,388,921 A 6/1983 Sutter et al.
4,408,601 A 10/1983 Wenk
RE31,628 E 7/1984 Allgower et al.
4,484,570 A 11/1984 Sutter et al.
4,493,317 A 1/1985 Klaue
4,513,744 A 4/1985 Klaue
4,535,658 A 8/1985 Molinari
4,564,007 A 1/1986 Coombs et al.
4,565,193 A 1/1986 Streli
4,573,458 A 3/1986 Lower
4,683,878 A 8/1987 Carter
4,704,929 A 11/1987 Osada
4,791,918 A 12/1988 Von Hasselbeck
4,794,918 A 1/1989 Wolter
4,838,252 A 6/1989 Klaue
4,927,421 A 5/1990 Goble et al.
4,978,349 A 12/1990 Frigg
4,988,350 A 1/1991 Herzberg
5,002,544 A 3/1991 Klaue et al.
5,006,120 A 4/1991 Carter
5,041,114 A 8/1991 Chapman et al.
5,053,036 A 10/1991 Perren et al.
5,085,660 A 2/1992 Lin
5,129,901 A 7/1992 Decoste
5,151,103 A 9/1992 Tepic et al.
5,190,544 A 3/1993 Chapman et al.
5,192,281 A 3/1993 de la Caffiniere
5,197,966 A 3/1993 Sommerkamp
5,198,308 A 3/1993 Shetty et al.
5,237,893 A 8/1993 Ryder et al.
5,259,398 A 11/1993 Vrespa
5,269,784 A 12/1993 Mast
5,275,601 A 1/1994 Gogolewski et al.
5,304,180 A 4/1994 Slocum
5,312,410 A 5/1994 Miller et al.
5,324,290 A 6/1994 Zdeblick et al.
5,324,291 A 6/1994 Ries et al.
5,356,410 A 10/1994 Pennig
5,360,452 A 11/1994 Engelhardt et al.
5,364,398 A 11/1994 Chapman et al.
5,364,399 A 11/1994 Lowery et al.
5,395,374 A 3/1995 Miller et al.
5,415,658 A 5/1995 Kilpela et al.
5,423,820 A 6/1995 Miller et al.
5,423,826 A 6/1995 Coates et al.
5,429,641 A 7/1995 Gotfried
5,431,659 A 7/1995 Ross et al.
5,470,333 A 11/1995 Ray
5,474,553 A 12/1995 Baumgart
5,487,743 A 1/1996 Laurain et al.
5,514,138 A 5/1996 McCarthy
5,520,690 A 5/1996 Errico et al.
5,522,902 A 6/1996 Yuan et al.
5,527,310 A 6/1996 Cole et al.
5,531,143 A 7/1996 Habermehl et al.
5,531,746 A 7/1996 Errico et al.
5,531,748 A 7/1996 de la Caffiniere
5,534,932 A 7/1996 Van de Waterlaat et al.
5,536,127 A 7/1996 Pennig
5,569,253 A 10/1996 Farris et al.
5,578,034 A 11/1996 Estes
5,591,168 A 1/1997 Judet et al.
5,601,553 A 2/1997 Trebing et al.
5,607,426 A 3/1997 Ralph et al.
5,607,428 A 3/1997 Lin
5,643,265 A 7/1997 Errico et al.
5,647,873 A 7/1997 Errico et al.
5,665,088 A 9/1997 Gil et al.
5,665,089 A 9/1997 Dall et al.
5,676,667 A 10/1997 Hausman
5,702,399 A 12/1997 Kilpela et al.
5,709,686 A 1/1998 Talos et al.
5,713,900 A 2/1998 Benzel et al.
5,725,588 A 3/1998 Errico et al.
5,733,287 A 3/1998 Tepic et al.
5,735,853 A 4/1998 Olerud
5,741,258 A 4/1998 Klaue et al.
5,749,872 A 5/1998 Kyle et al.
5,769,850 A 6/1998 Chin
5,772,662 A 6/1998 Chapman et al.
5,776,196 A 7/1998 Matsuzaki et al.
5,788,697 A 8/1998 Kilpela et al.
5,797,912 A 8/1998 Runciman et al.
5,810,823 A 9/1998 Klaue et al.
5,824,247 A 10/1998 Tunc
5,876,402 A 3/1999 Errico et al.
5,888,204 A 3/1999 Ralph et al.
5,893,856 A 4/1999 Jacob et al.
5,902,305 A 5/1999 Beger et al.
5,904,683 A 5/1999 Pohndorf et al.
5,904,684 A 5/1999 Rooks
5,925,047 A 7/1999 Errico et al.
5,935,130 A 8/1999 Kilpela et al.
5,935,133 A 8/1999 Wagner et al.
5,938,664 A 8/1999 Winquist et al.
5,954,722 A 9/1999 Bono
5,960,681 A 10/1999 Anderson et al.
5,961,524 A 10/1999 Crombie
5,964,769 A 10/1999 Wagner et al.
5,968,046 A 10/1999 Castleman

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,968,047	A	10/1999	Reed	
5,976,141	A	11/1999	Haag et al.	
6,016,727	A	1/2000	Morgan	
6,019,762	A	2/2000	Cole	
6,022,352	A	2/2000	Vandewalle	
6,053,921	A	4/2000	Wagner et al.	
6,096,040	A	8/2000	Esser	
6,129,730	A	10/2000	Bono et al.	
6,176,861	B1	1/2001	Bernstein et al.	
6,183,475	B1	2/2001	Lester et al.	
6,193,721	B1	2/2001	Michelson	
6,206,881	B1	3/2001	Frigg et al.	
6,214,049	B1	4/2001	Gayer et al.	
6,228,085	B1	5/2001	Theken et al.	
6,235,033	B1	5/2001	Brace et al.	
RE37,249	E	6/2001	Leibinger et al.	
6,258,092	B1	7/2001	Dall	
6,273,889	B1	8/2001	Richelsoph	
6,302,001	B1	10/2001	Karle	
6,302,883	B1	10/2001	Bono	
6,306,136	B1	10/2001	Baccelli	
6,306,140	B1	10/2001	Siddiqui	
6,309,393	B1	10/2001	Tepic et al.	
6,322,562	B1	11/2001	Wolter	
6,342,055	B1	1/2002	Eisermann et al.	
6,355,041	B1	3/2002	Martin	
6,355,043	B1	3/2002	Adam	
6,358,250	B1	3/2002	Orbay	
6,361,537	B1	3/2002	Anderson	
6,364,885	B1	4/2002	Kilpela et al.	
6,370,091	B1	4/2002	Kuroda	
6,379,359	B1	4/2002	Dahners	
6,386,808	B2	5/2002	Fujii et al.	
6,391,030	B1	5/2002	Wagner et al.	
6,413,259	B1	7/2002	Lyons et al.	
6,428,542	B1	8/2002	Michelson	
6,436,100	B1	8/2002	Berger	
6,440,135	B2	8/2002	Orbay et al.	
6,454,769	B2	9/2002	Wagner et al.	
6,454,770	B1	9/2002	Klaue	
6,468,278	B1	10/2002	Muckter	
6,475,218	B2	11/2002	Gournay et al.	
6,506,191	B1	1/2003	Joos	
6,520,965	B2	2/2003	Chervitz et al.	
6,524,238	B2	2/2003	Velikaris et al.	
6,527,776	B1	3/2003	Michelson	
6,558,387	B2	5/2003	Errico et al.	
6,575,975	B2	6/2003	Brace et al.	
6,595,993	B2	7/2003	Donno et al.	
6,595,994	B2	7/2003	Kilpela et al.	
6,605,090	B1	8/2003	Trieu et al.	
6,623,486	B1	9/2003	Weaver et al.	
6,669,700	B1	12/2003	Farris et al.	
6,669,701	B2	12/2003	Steiner et al.	
6,682,531	B2	1/2004	Winquist et al.	
6,682,533	B1	1/2004	Dinsdale et al.	
6,684,741	B2	2/2004	Blackston	
6,689,133	B2	2/2004	Morrison et al.	
6,719,759	B2	4/2004	Wagner et al.	
6,730,091	B1	5/2004	Pfefferle et al.	
6,755,829	B1	6/2004	Bono et al.	
6,767,351	B2	7/2004	Orbay et al.	
6,780,186	B2	8/2004	Errico et al.	
6,821,278	B2	11/2004	Frigg et al.	
6,866,665	B2	3/2005	Orbay	
6,893,443	B2	5/2005	Frigg et al.	
6,893,444	B2	5/2005	Orbay	
6,916,320	B2	7/2005	Michelson	
6,945,975	B2	9/2005	Dalton	
6,955,677	B2	10/2005	Dahners	
6,960,213	B2	11/2005	Chervitz et al.	
6,969,390	B2	11/2005	Michelson	
6,973,860	B2	12/2005	Nish	
6,974,461	B1	12/2005	Wolter	
6,979,334	B2	12/2005	Dalton	
7,073,415	B2	7/2006	Casutt et al.	
7,074,221	B2	7/2006	Michelson	
7,128,744	B2	10/2006	Weaver et al.	
7,172,593	B2	2/2007	Trieu et al.	
7,179,260	B2	2/2007	Gerlach et al.	
7,230,039	B2	6/2007	Trieu et al.	
7,250,053	B2	7/2007	Orbay	
7,250,054	B2	7/2007	Allen et al.	
7,255,701	B2	8/2007	Allen et al.	
7,282,053	B2	10/2007	Orbay	
7,294,130	B2	11/2007	Orbay	
7,341,589	B2	3/2008	Weaver et al.	
7,419,714	B1	9/2008	Magerl et al.	
7,695,472	B2	4/2010	Young	
7,722,653	B2 *	5/2010	Young et al.	606/280
7,766,948	B1	8/2010	Leung	
2001/0037112	A1	11/2001	Brace et al.	
2001/0047174	A1	11/2001	Donno et al.	
2002/0013587	A1	1/2002	Winquist et al.	
2002/0045901	A1	4/2002	Wagner et al.	
2002/0058940	A1	5/2002	Frigg et al.	
2002/0058943	A1	5/2002	Kilpela et al.	
2002/0115742	A1	8/2002	Trieu et al.	
2002/0143338	A1	10/2002	Orbay et al.	
2002/0161370	A1	10/2002	Frigg et al.	
2003/0040749	A1	2/2003	Grabowski et al.	
2003/0057590	A1	3/2003	Loher et al.	
2003/0060827	A1	3/2003	Coughln	
2003/0105462	A1	6/2003	Haider	
2003/0183335	A1	10/2003	Winniczek et al.	
2004/0010257	A1	1/2004	Cachia et al.	
2004/0030342	A1	2/2004	Trieu et al.	
2004/0044345	A1	3/2004	DeMoss et al.	
2004/0059334	A1	3/2004	Weaver et al.	
2004/0059335	A1	3/2004	Weaver et al.	
2004/0073218	A1	4/2004	Dahners	
2004/0087954	A1	5/2004	Allen et al.	
2004/0097942	A1	5/2004	Allen et al.	
2004/0138666	A1	7/2004	Molz et al.	
2004/0181228	A1	9/2004	Wagner et al.	
2004/0199169	A1	10/2004	Koons et al.	
2004/0215195	A1	10/2004	Shipp et al.	
2004/0220570	A1	11/2004	Frigg	
2004/0236332	A1	11/2004	Frigg	
2004/0260306	A1	12/2004	Fallin et al.	
2005/0010220	A1	1/2005	Casutt et al.	
2005/0010226	A1	1/2005	Grady et al.	
2005/0027298	A1	2/2005	Michelson	
2005/0043736	A1	2/2005	Mathieu et al.	
2005/0049593	A1	3/2005	Duong et al.	
2005/0070904	A1	3/2005	Gerlach et al.	
2005/0080421	A1	4/2005	Weaver et al.	
2005/0107796	A1	5/2005	Gerlach et al.	
2005/0149026	A1	7/2005	Butler et al.	
2005/0165400	A1	7/2005	Fernandez	
2005/0192580	A1	9/2005	Dalton	
2005/0234457	A1	10/2005	James et al.	
2005/0261688	A1	11/2005	Grady et al.	
2005/0277937	A1	12/2005	Leung et al.	
2005/0283154	A1	12/2005	Orbay et al.	
2006/0004361	A1	1/2006	Hayeck et al.	
2006/0009770	A1	1/2006	Speirs et al.	
2006/0009771	A1	1/2006	Orbay et al.	
2006/0095040	A1	5/2006	Schlienger et al.	
2006/0116678	A1	6/2006	Impellizzeri	
2006/0122602	A1	6/2006	Konieczynski et al.	
2006/0129148	A1	6/2006	Simmons et al.	
2006/0129151	A1	6/2006	Allen et al.	
2006/0149265	A1	7/2006	James et al.	
2006/0165400	A1	7/2006	Spencer	
2006/0167464	A1	7/2006	Allen et al.	
2006/0200147	A1	9/2006	Ensign et al.	
2006/0235400	A1	10/2006	Schneider	
2006/0235410	A1	10/2006	Ralph et al.	
2006/0259039	A1	11/2006	Pitkanen et al.	
2007/0010817	A1	1/2007	de Coninck	
2007/0043366	A1	2/2007	Pfefferle et al.	
2007/0093836	A1	4/2007	Derouet	
2007/0161995	A1	7/2007	Trautwein et al.	

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0162016	A1	7/2007	Matityahu
2007/0162020	A1	7/2007	Gerlach et al.
2007/0185488	A1	8/2007	Pohjonen et al.
2007/0213828	A1	9/2007	Trieu et al.
2007/0233106	A1	10/2007	Horan et al.
2007/0260244	A1	11/2007	Wolter et al.
2007/0270691	A1	11/2007	Bailey et al.
2007/0270832	A1	11/2007	Moore
2007/0270833	A1	11/2007	Bonutti et al.
2007/0276383	A1	11/2007	Rayhack
2008/0021474	A1	1/2008	Bonutti et al.
2008/0039845	A1	2/2008	Bonutti et al.
2008/0086129	A1	4/2008	Lindermann et al.
2008/0140130	A1	6/2008	Chan et al.
2008/0154367	A1	6/2008	Justis et al.
2008/0154368	A1	6/2008	Justis et al.
2008/0154373	A1	6/2008	Protopsaltis et al.
2008/0167717	A9	7/2008	Trieu et al.
2008/0208259	A1	8/2008	Gilbert et al.
2008/0300637	A1	12/2008	Austin et al.
2009/0024161	A1	1/2009	Bonutti et al.
2009/0076553	A1	3/2009	Wolter et al.
2009/0088807	A1	4/2009	Castaneda et al.
2009/0143824	A1	6/2009	Austin et al.
2009/0149888	A1	6/2009	Abdelgany
2009/0192549	A1	7/2009	Sanders et al.
2009/0312803	A1	12/2009	Austin et al.
2012/0143193	A1	6/2012	Hulliger

FOREIGN PATENT DOCUMENTS

CA	2408327	3/2001
CA	2536960	3/2005
CH	611147	5/1979
CN	1373646	10/2002
CN	1380043	11/2002
CN	1188086	2/2005
CN	1331572	8/2007
CN	101022767	8/2007
DE	323214	7/1920
DE	2602900	4/1979
DE	3513600	10/1986
DE	3804749	3/1989
DE	3832343	3/1990
DE	9000161	4/1990
DE	4341980	6/1995
DE	4343117	6/1995
DE	4438261	9/1995
DE	4438264	11/1996
DE	19629011	1/1998
DE	19962317	3/2001
DE	102004035546	2/2006
DE	19858889	8/2008
EP	0201024	11/1986
EP	0207884	1/1987
EP	0274713	7/1988
EP	0355035	2/1990
EP	0468192	4/1992
EP	0486762	5/1995
EP	0530585	12/1995
EP	0705572	4/1996
EP	0760632	3/1997
EP	0799124	8/2001
EP	1143867	10/2001
EP	1211992	6/2002
EP	1211993	6/2002
EP	1211994	6/2002
EP	1330209	7/2003
EP	0828459	9/2003
EP	1364623	11/2003
EP	1404492	4/2004
EP	1169971	10/2004
EP	1649819	4/2006
EP	1658015	5/2006
EP	1711114	10/2006
EP	1093385	12/2006
EP	1764054	3/2007
EP	1776055	4/2007
EP	1813292	8/2007
EP	1857073	11/2007
EP	1718229	4/2008
EP	1931268	6/2008
EP	2019639	2/2009
EP	1988837	12/2011
FR	2233973	1/1975
FR	2254298	7/1975
FR	2405062	5/1979
FR	2405705	5/1979
FR	2405706	5/1979
FR	2496429	6/1982
FR	2501032	9/1982
FR	2501033	10/1985
FR	2667913	4/1992
FR	2698261	3/1995
FR	2706763	8/1995
FR	2739151	11/1997
FR	2757370	6/1998
FR	2802082	6/2001
FR	2831792	7/2004
FR	2890848	11/2007
GB	580571	9/1946
JP	2003509107	3/2003
RU	2234878	8/2004
SU	1279626	12/1986
TW	477687	3/2002
WO	WO8904150	5/1989
WO	WO9007304	7/1990
WO	WO9609014	3/1996
WO	WO9619336	6/1996
WO	WO9625892	8/1996
WO	WO9629948	10/1996
WO	WO9709000	3/1997
WO	WO9834553	8/1998
WO	WO9834556	8/1998
WO	WO9905968	2/1999
WO	WO9925266	5/1999
WO	WO9961081	12/1999
WO	WO0018309	4/2000
WO	WO0019264	4/2000
WO	WO0036984	6/2000
WO	WO0053110	9/2000
WO	WO0053111	9/2000
WO	WO0066012	11/2000
WO	WO0119267	3/2001
WO	WO0119268	3/2001
WO	WO0119264	8/2001
WO	WO0178615	10/2001
WO	WO0191660	12/2001
WO	WO0200127	1/2002
WO	WO02058574	8/2002
WO	WO02068009	9/2002
WO	WO02034159	11/2002
WO	WO02096309	12/2002
WO	WO03006210	1/2003
WO	WO03106110	12/2003
WO	WO2004032726	4/2004
WO	WO2004032751	5/2004
WO	WO2004086990	10/2004
WO	WO2004089233 A1	10/2004
WO	WO2005018471	3/2005
WO	WO2005018472	3/2005
WO	WO2005032386	4/2005
WO	WO2005034722	4/2005
WO	WO2005079685	9/2005
WO	WO2005062902	12/2005
WO	WO2006007965	1/2006
WO	WO2006039636	4/2006
WO	WO2006068775	6/2006
WO	WO2007014279	2/2007
WO	WO2007025520	3/2007
WO	WO2007041686	4/2007
WO	WO2007014192	5/2007
WO	WO2007092869	8/2007

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO2007130840	11/2007
WO	WO2008033742	3/2008
WO	WO2008022136	4/2008
WO	WO2008064211	5/2008
WO	WO2008077137	6/2008
WO	WO2008079846	7/2008
WO	WO2008079864	7/2008
WO	WO2008116203	12/2008
WO	WO2009029908	3/2009

OTHER PUBLICATIONS

Smith & Nephew Brochure entitled 'Surgical Technique PERI-LOC VLP Variable-Angle Locked Plating System,' pp. 1-32 (Nov. 2007).
Smith & Nephew Brochure entitled 'PERI-LOC VLP Variable-Angle Locked Plating System Distal Tibia Locking Plates,' 04 pages (Oct. 2007).
Smith & Nephew Brochure entitled 'PERI-LaC VLP Variable-Angle Locked Plating System Distal Fibula Locking Plates,' 04 pages (Oct. 2007).
Smith & Nephew Brochure entitled 'PERI-LaC VLP Variable-Angle Locked Plating System Proximal Tibia Locking Plates,' 04 pages (Oct. 2007).
Smith & Nephew Brochure entitled 'PERI•LOC VLP Variable•Angle Locked Plating System Proximal Tibia Variable-Angle Locking Plates,' 04 pages (Nov. 2007).
Smith & Nephew Brochure entitled 'PERI-LaC VLP Variable-Angle Locked Plating System Improved Torsional Fatigue Properties with Thin Locked Versus Non-Locked Plate Constructs for Fixation of Simulated Osteoporotic Distal Fibula Fractures,' 04 pages (Nov. 2007).
Winkelstabilitat, litos Unidirectional locking screw technology, Jan. 15, 2008, 5 pages http://www.litos.com/pages/winkelstabilitaet e.html.
"SMARTLock Locking Screw Technology," http://www.stryker.com/microimplants/products/cmf smartlock.phn, Mar. 14, 2004.
International Search Report for PCT/US200S/028778, dated Apr. 19, 2007.
"Fracture and Dislocation Compendium," Orthopaedic Trauma Association Committee for Coding and Classification, Journal of Orthopaedic Trauma, vol. 10, Suppl.,jp, v = ix, 1996.
English Abstract of JP 2002532185, Published Oct. 2, 2002.
English Abstract of ZA 200200992, Published Dec. 18, 2002, Applicant: SYNTHES AG.
NCB® Proximal Humerus Plating System, Surgical Technique, Zimmer, Inc. 2005.
Zimmer® NCB® Plating System, Zimmer, Inc. 2006.
NCB® Distal Femoral Plating System, Surgical Technique, Zimmer, Inc. 2005.
New Trauma Products from AO Development, News—No. 1, 2007.
Office Action for Japanese Application No. 2008-0524048 mailed Oct. 25, 2011, 6 pages.
Office Action for U.S. Appl. No. 12/069,331 mailed Aug. 23, 2011, 12 pages.
International Preliminary Report on Patentability for International Application No. PCT/US2006/028778, mailed Jan. 28, 2008, 9 pages.
Office Action for U.S. Appl. No. 12/484,527, mailed May 18, 2011, 10 pages.
Office Action for U.S. Appl. No. 12/484,527, mailed Jan. 20, 2011, 9 pages.
DePuy brochure entitled "Every Surgeon has His or Her Own View," Stryker Numelock II® Polyaxial Locking System, Operative Technique, Gtrauma Application, 6 pages (undated).
"Polyax Wide Angle Freedom Surgical Technique Distal Femoral Locked Playing System," DePuy International Ltd., http://www/rcsed.ac.uk/fellows/Ivanrensburg/classification/surgtech/depuy (2005).
Machine Translation of EP 1649819.
DePuy Orthopaedics, Inc., "Surgical Technique Distal Femoral Locked Plating System," Polyax Wide Angle Freedom (2005).
Final Office Action for U.S. Appl. No. 12/069,331, mailed Apr. 9, 2012.
Office Action for U.S. Appl. No. 11/996,795, mailed Mar. 23, 2012.
Decision of Rejection for Japanese Application No. 2008-0524048, mailed Oct. 30, 2011.
Office Action for U.S. Appl. No. 11/996,795, mailed Nov. 21, 2012.
Fuchs, S., et al., "Titanium Fixative Plate System with Multidirectional Angular Stability in the Lower Leg and Foot," Trauma Berufskrankh, 2001-3 (Suppl 4): S447-S453, Springer-Verlag 2001, Certified English Translation Thereof.
Wolter, D., et al., "Titanium Internal Fixator for the Tibia," Trauma Berufskrankh, 2001-3 (Supp 2): S156-S161, Springer-Verlag 2001, Certified English Translation Thereof.
Jürgens, C., et al., "Special Indications for the Application of the Fixed Angle Internal Fixation in Femur Fractures," Trauma Berufskrankh (1999) 1:387,391, Springer-Verlag 1999, Certified English Translation Thereof.
Fuchs, S., et al., "Clinical Experiences with a New Internal Titanium Fixator for Ventral Spondylodesis of the Cervical Spine," Trauma Berufskrankh (1999) 1:382-386, Springer-Verlag 1999, Certified English Translation Thereof.
Kranz, H.-W., et al., "Internal Titanium Fixation of Tibial Pseudarthrosis, Malalignment, and Fractures," Trauma Berufskrankh (1999) 1:356-360, Springer-Verlag 1999, Certified English Translation Thereof.
Böhmer, G., et al., "TiFix® Angularly Stable Condylar Plate," Trauma Berufskrankh (1999) 1:351-355, Springer-Verlag 1999, Certified English Translation Thereof.
Wolter, D., et al., "Universal Internal Titanium Fixation Device," Trauma Berufskrankh (1999) 1:307-309, Springer-Verlag 1999, Certified English Translation Thereof.
Office Action for U.S. Appl. No. 13/524,506, mailed Dec. 16, 2013.
Notice of Reasons for Rejection for Japanese Application No. 2013-037623, mailed Mar. 3, 2014.
Australian Office Action in Application No. 2013202741, issued Feb. 3, 2014, 4 pages.

* cited by examiner

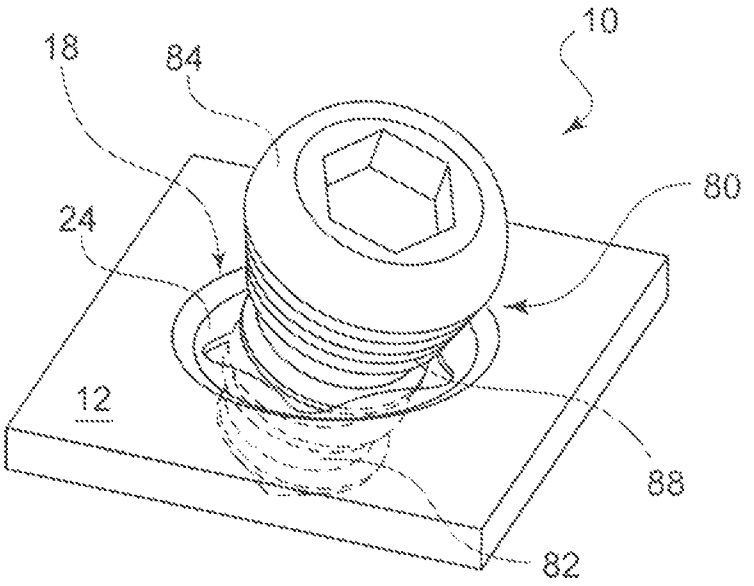


FIG. 1

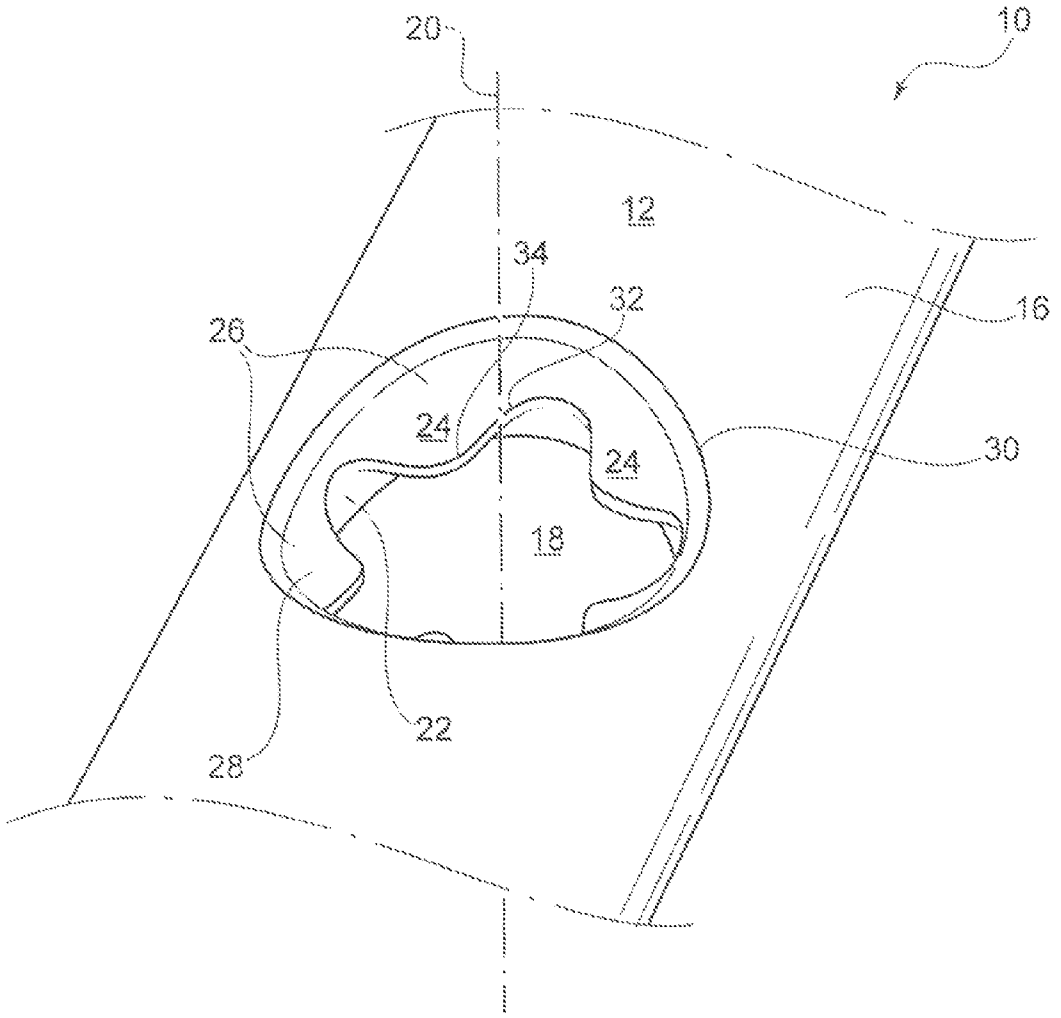


FIG. 2

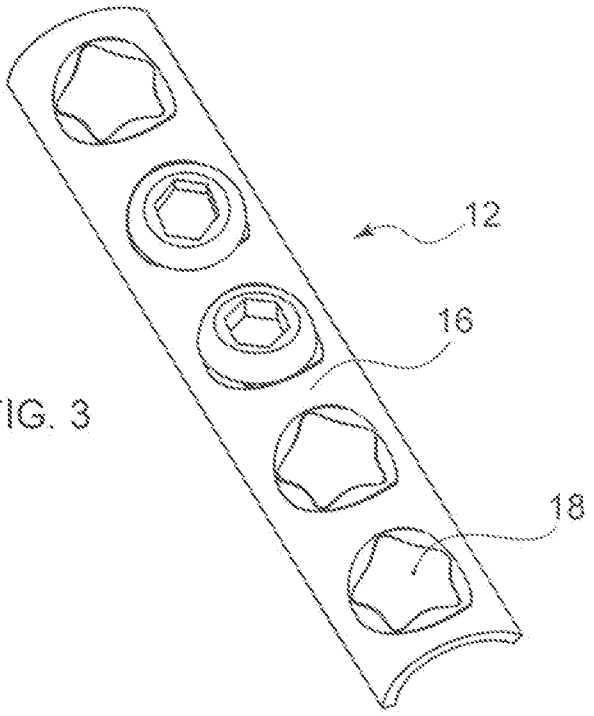


FIG. 3

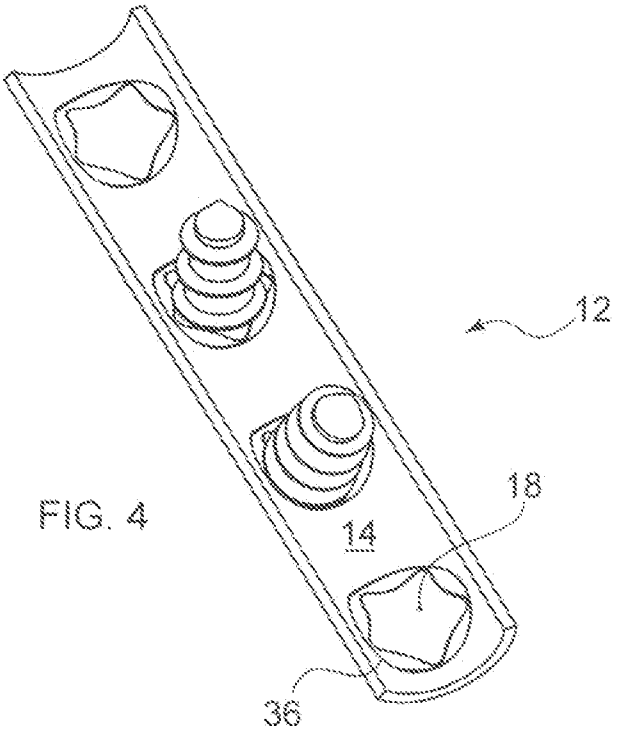


FIG. 4

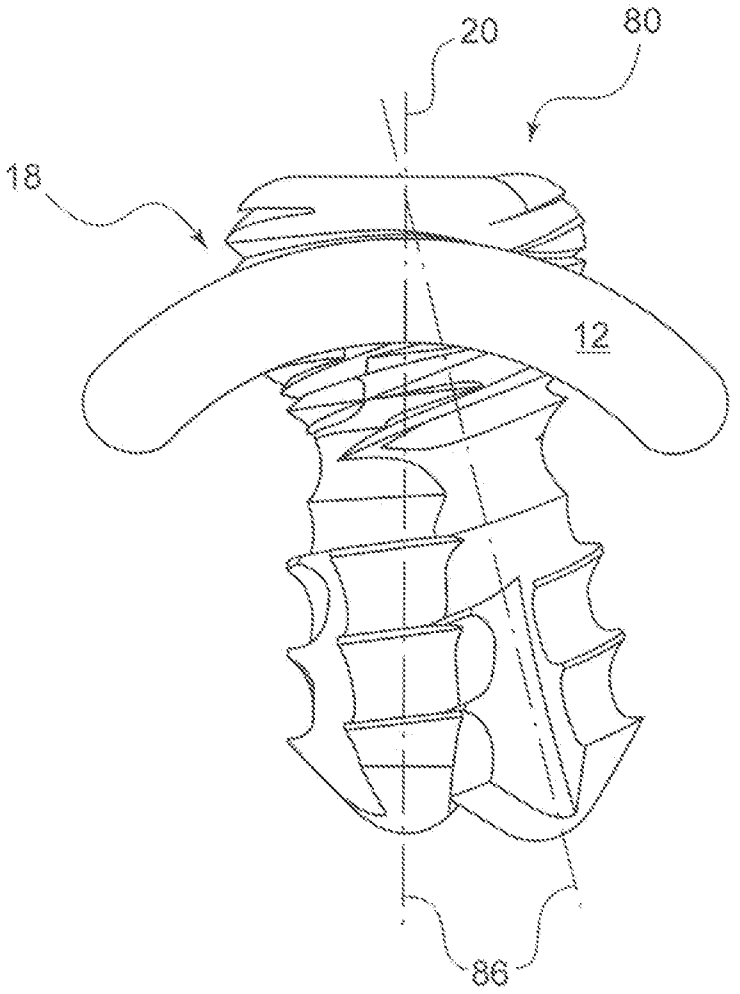


FIG. 5

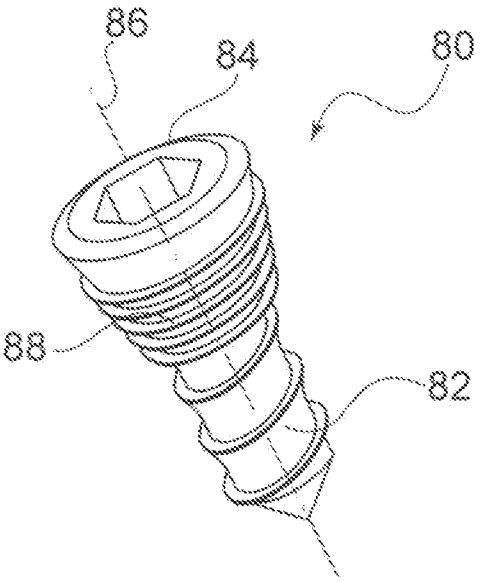


FIG. 6

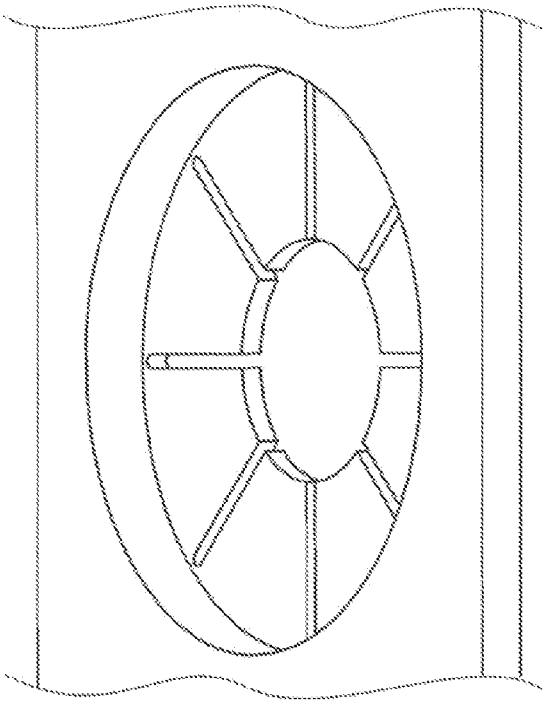


FIG. 8

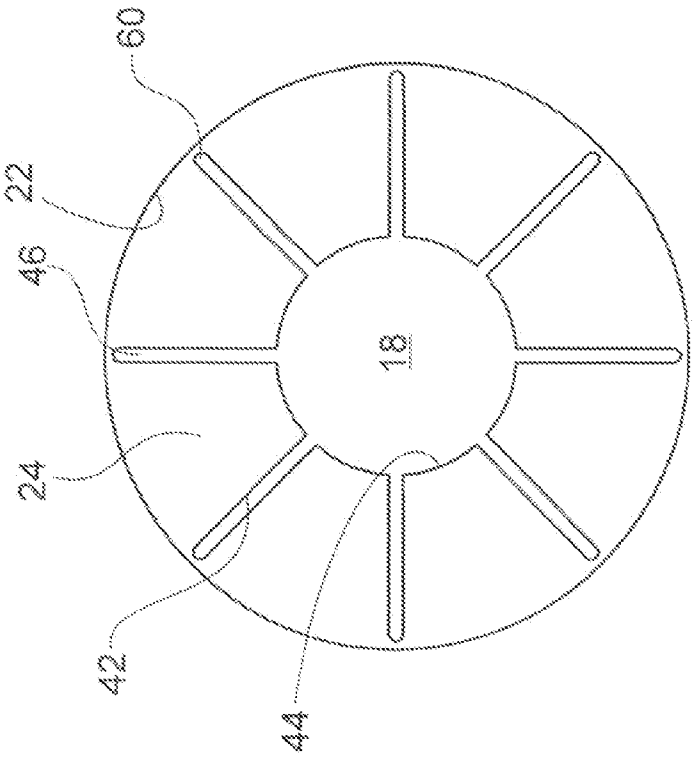


FIG. 7

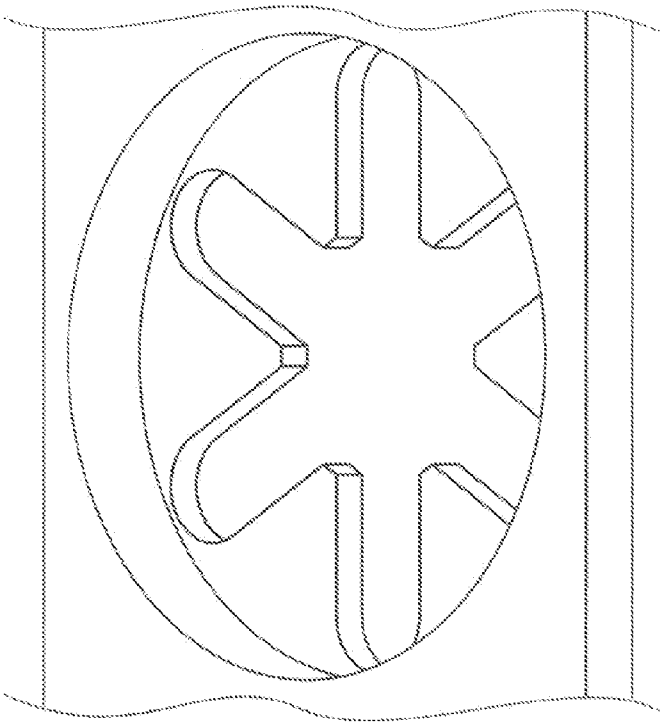


FIG. 10

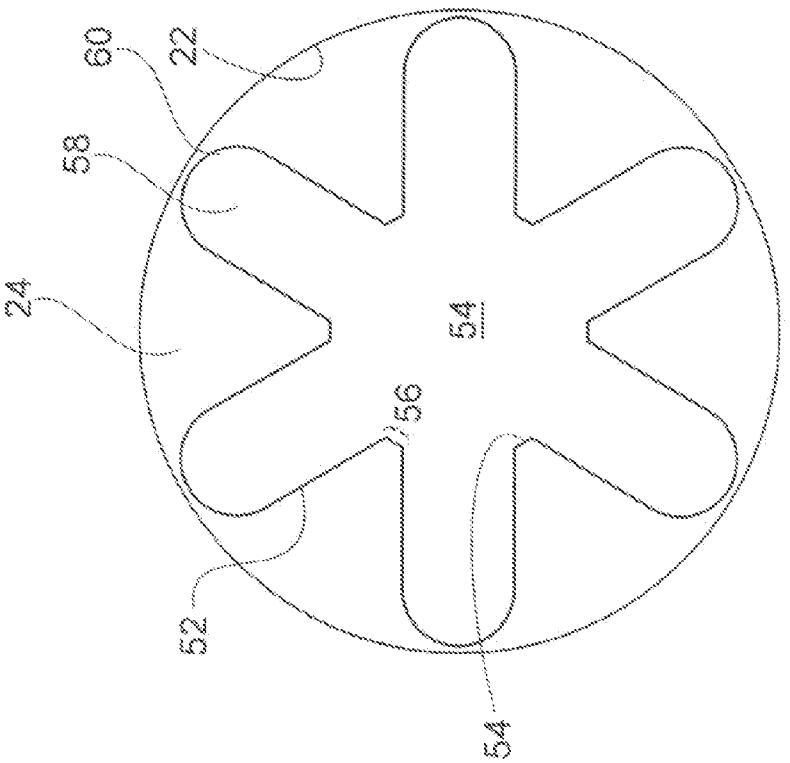


FIG. 9

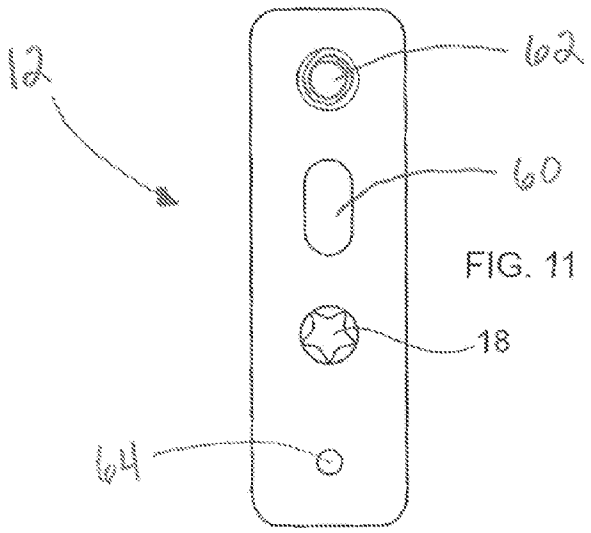


FIG. 11

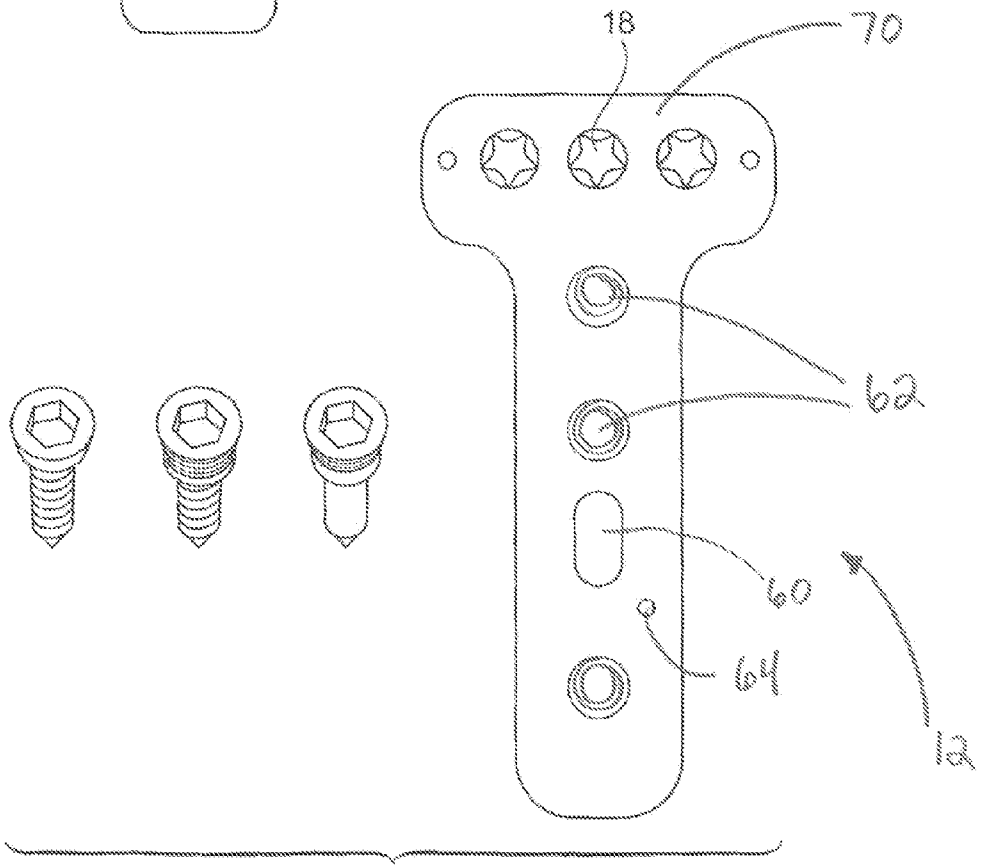


FIG. 12

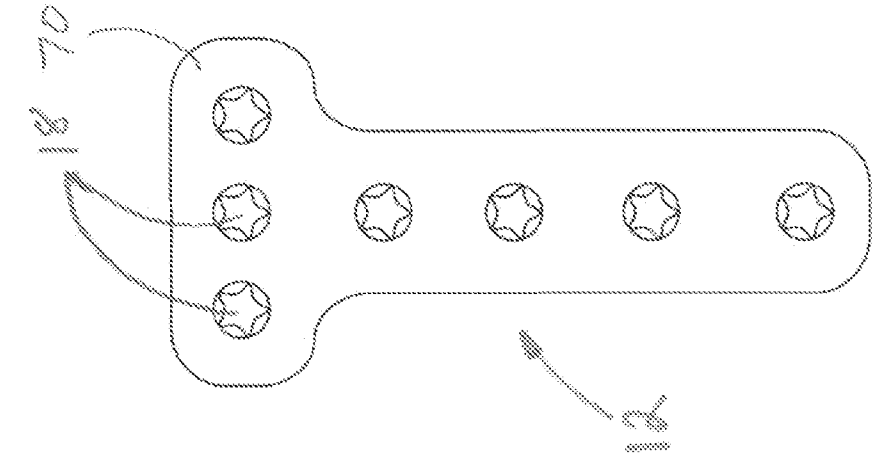


FIG. 15

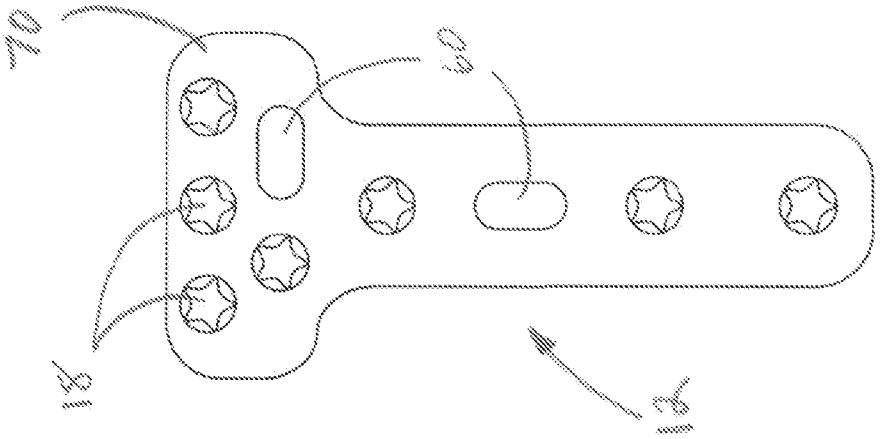


FIG. 14

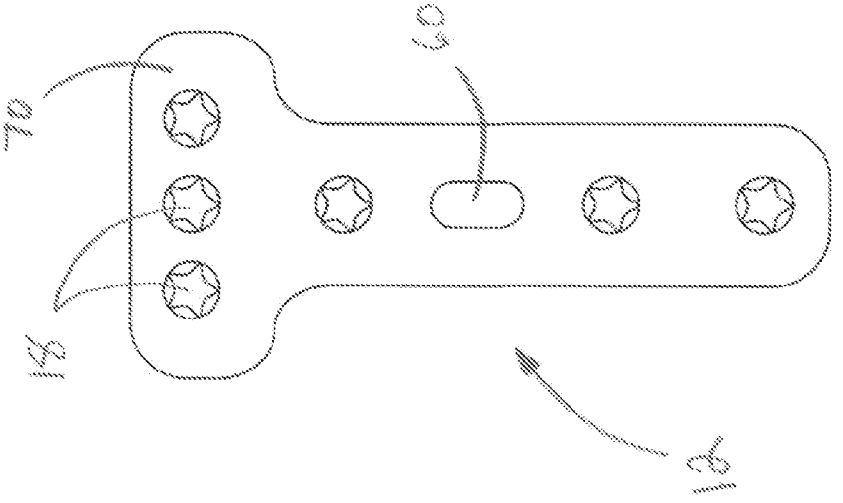


FIG. 13

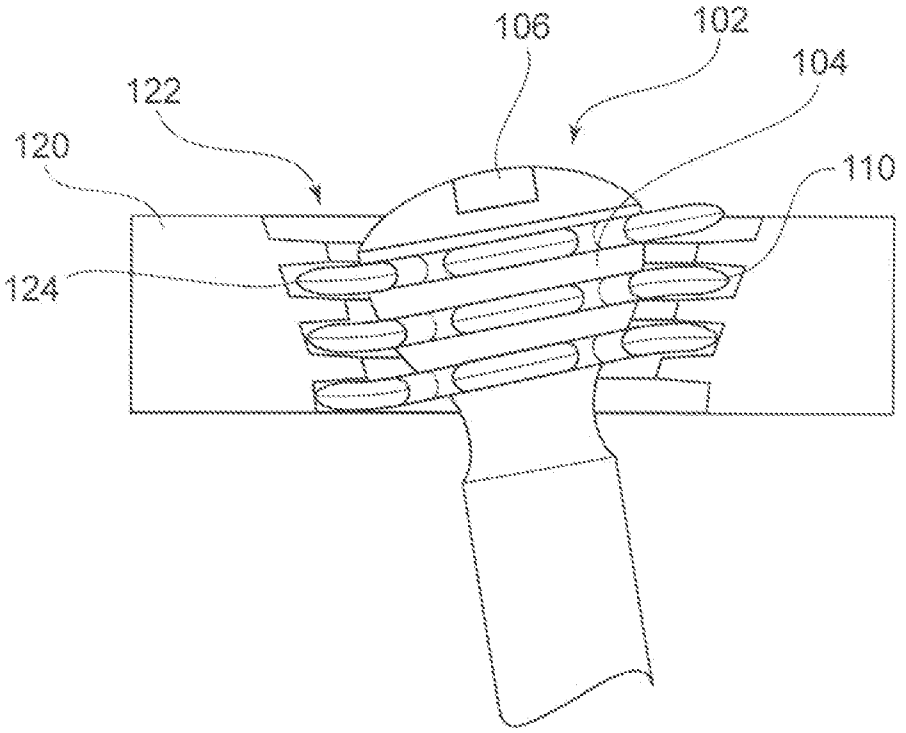


FIG. 16

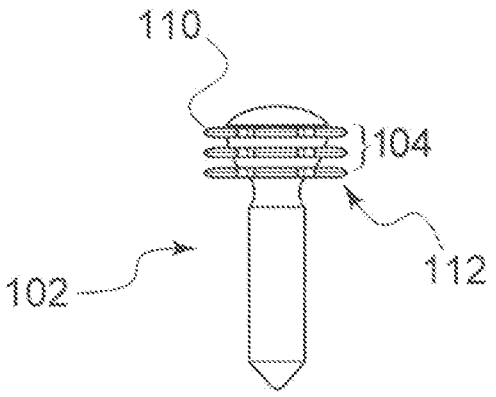


FIG. 17

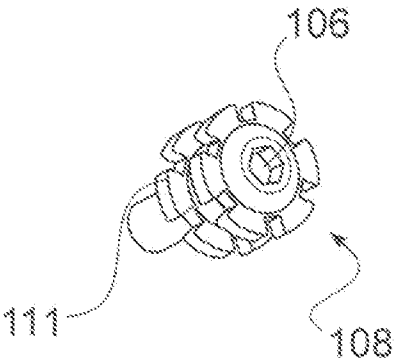


FIG. 18

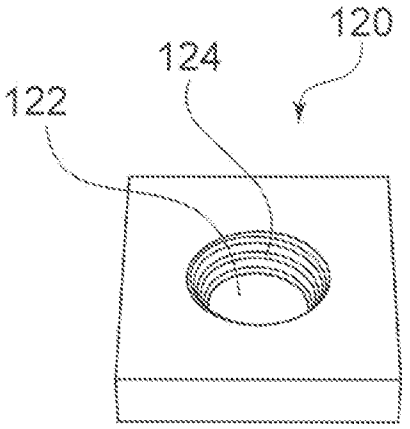


FIG. 19

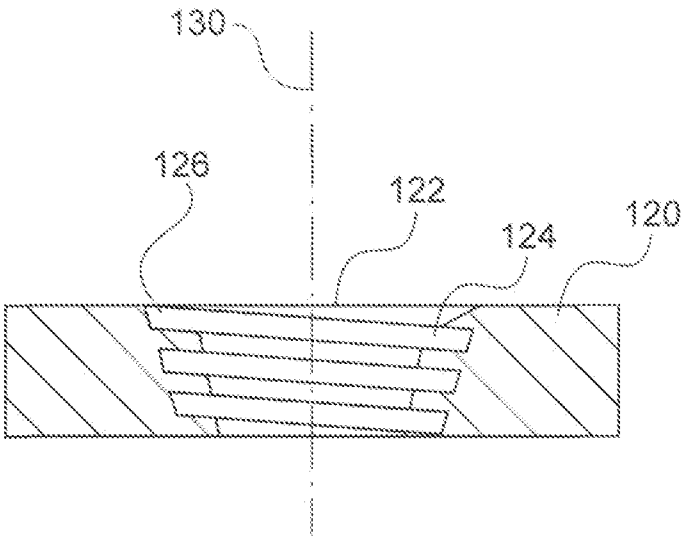


FIG. 20

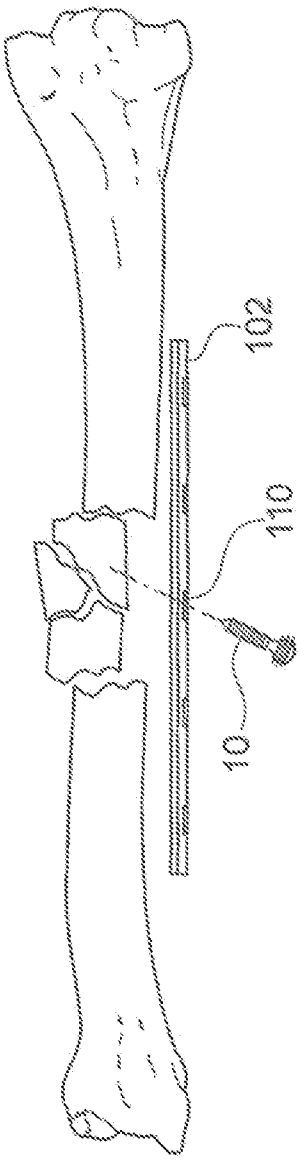


Fig. 21a

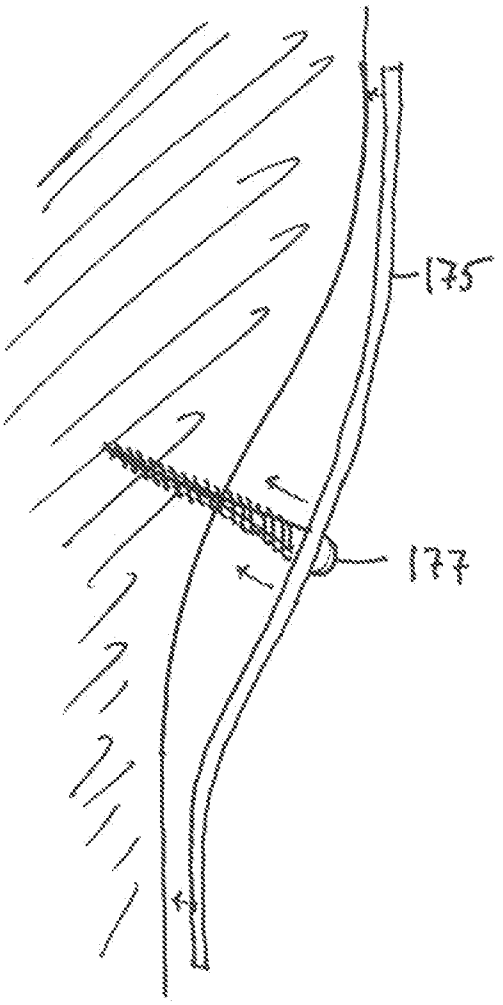


Fig. 21b

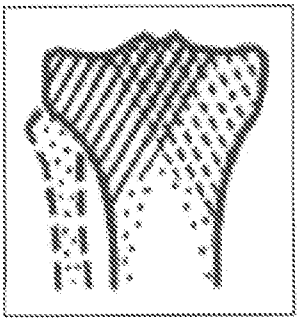
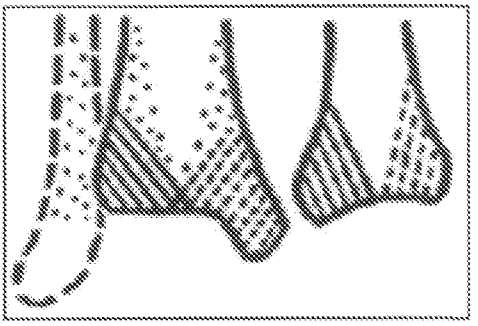


Fig. 22a

Partial articular (41-B)*



Partial articular (43-B)*

Fig. 22b

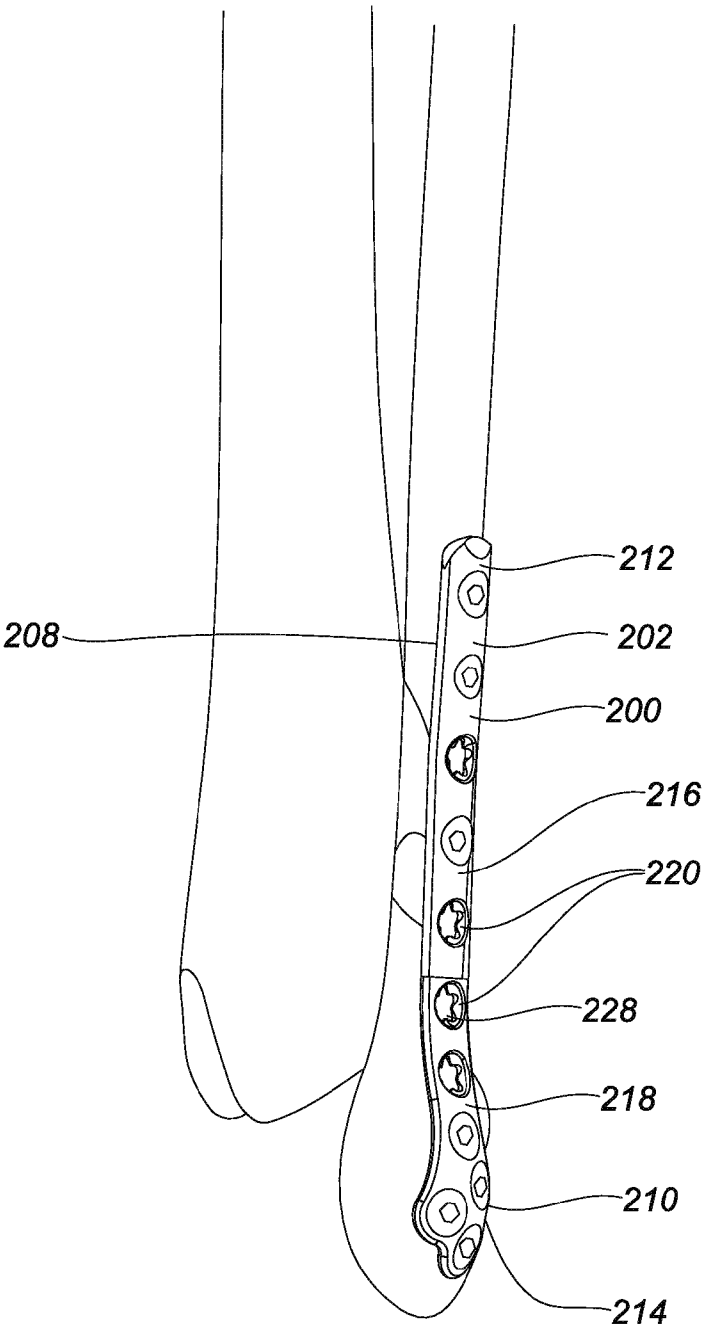


FIG. 23

FIG. 24A

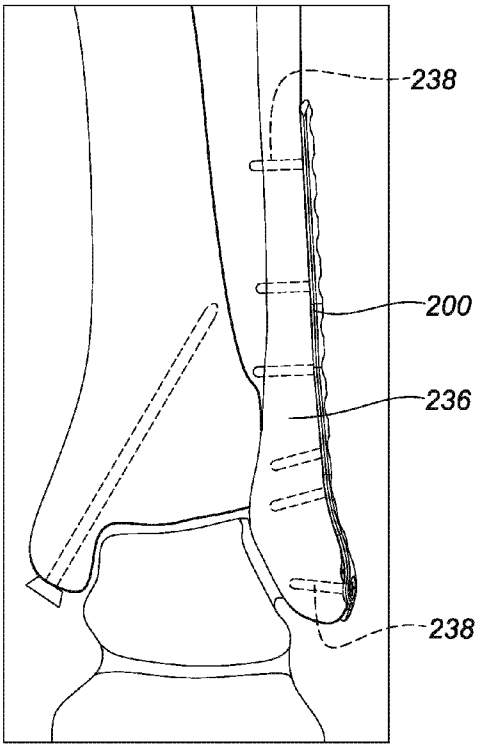


FIG. 24B

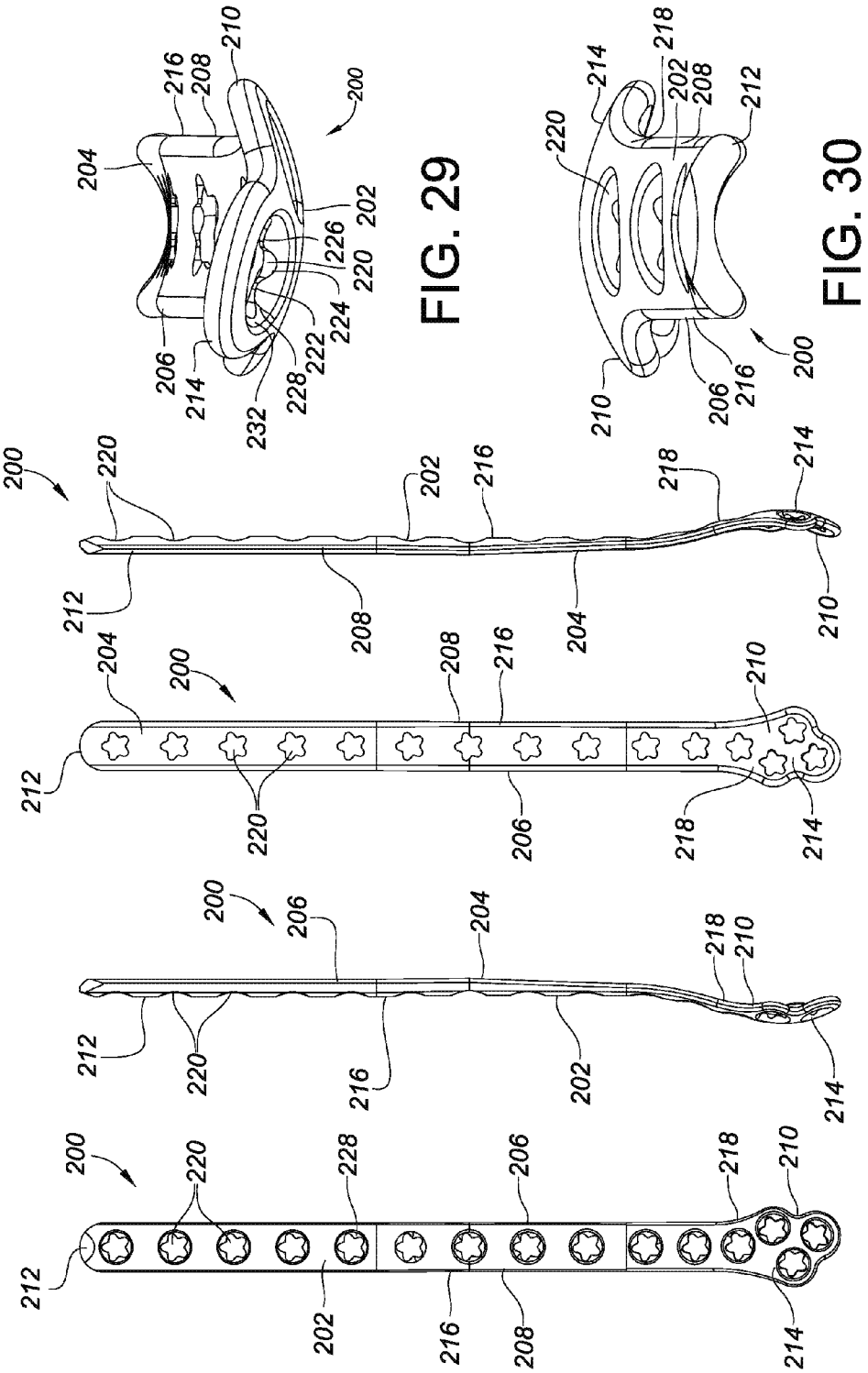


FIG. 25A FIG. 27 FIG. 26 FIG. 28

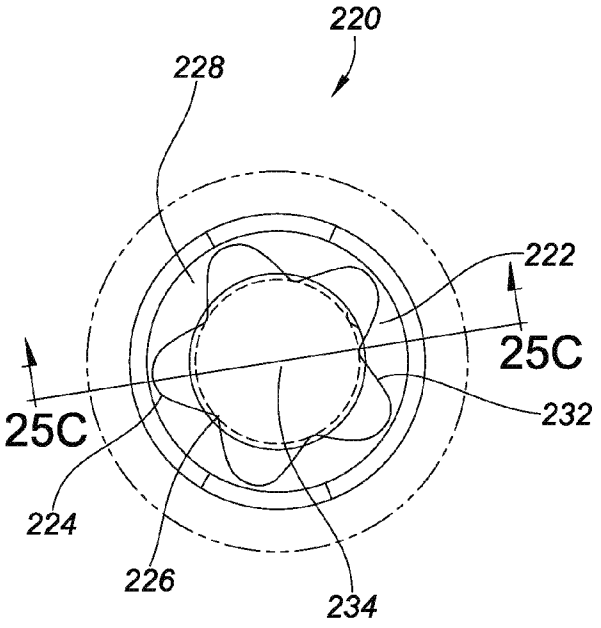


FIG. 25B

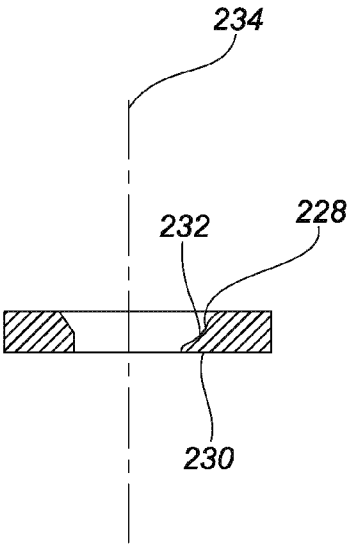


FIG. 25C

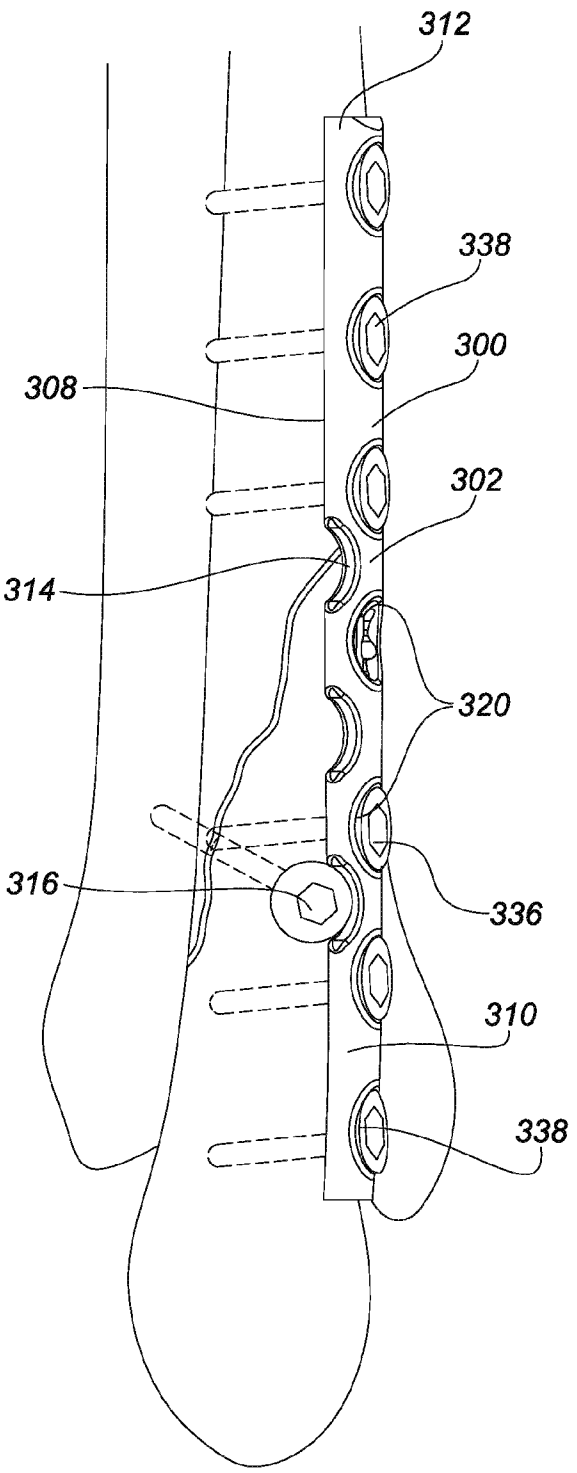


FIG. 31

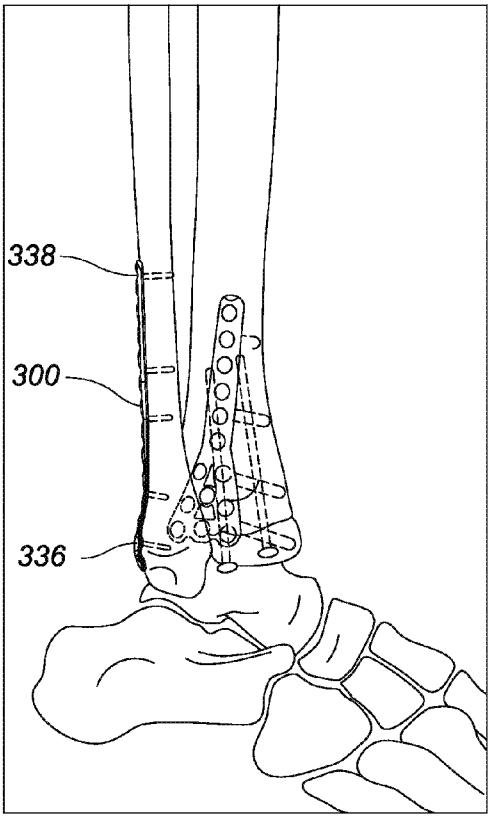


FIG. 32A

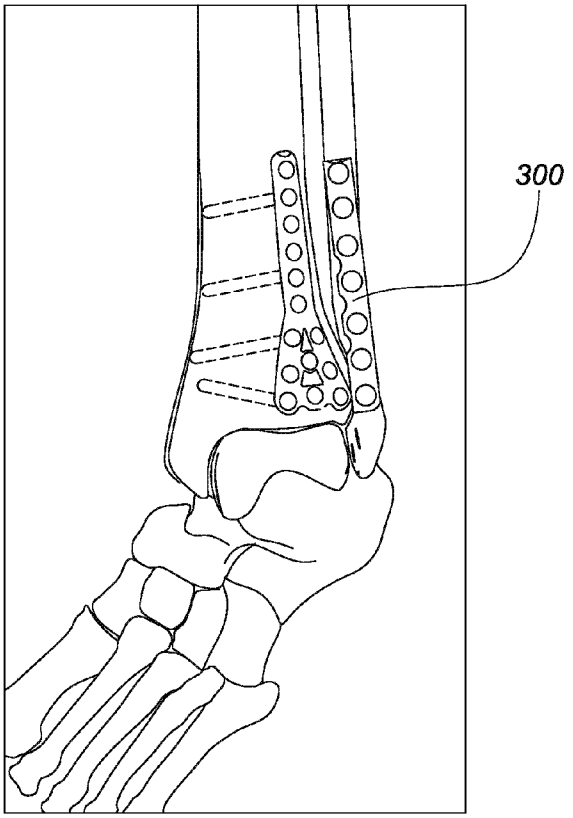


FIG. 32B

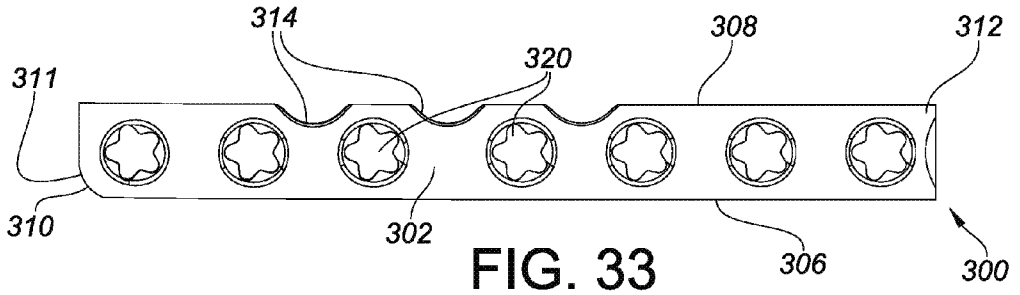


FIG. 33

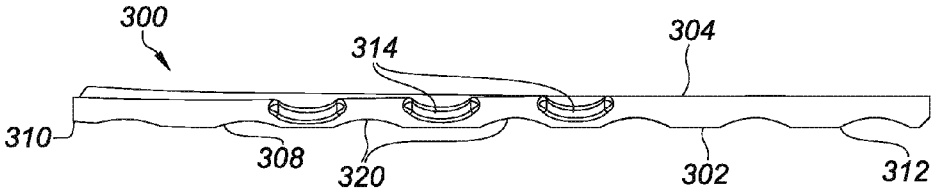


FIG. 35

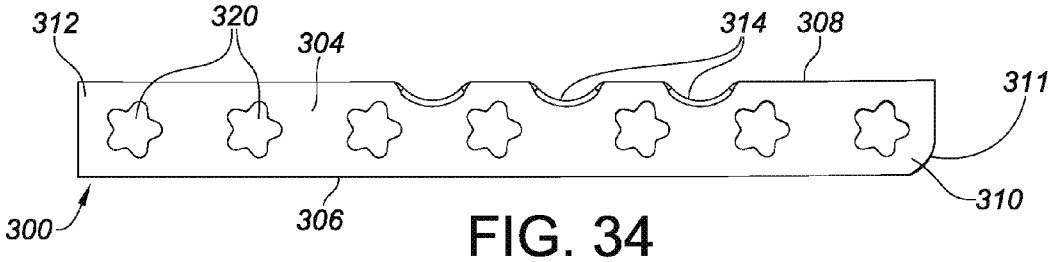


FIG. 34

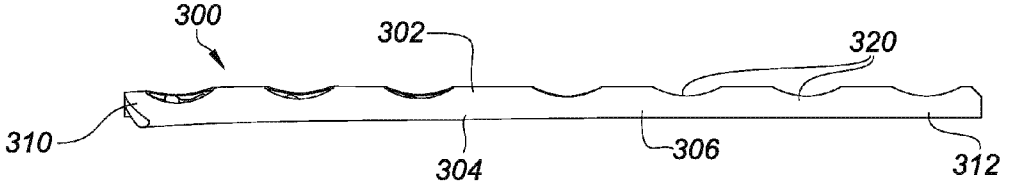


FIG. 36

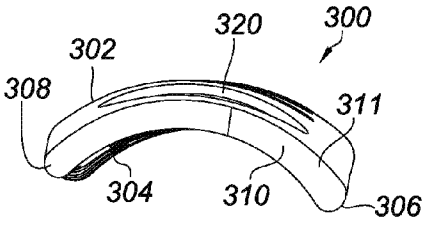


FIG. 37

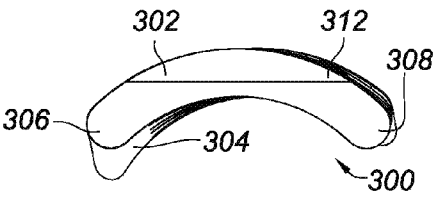


FIG. 38

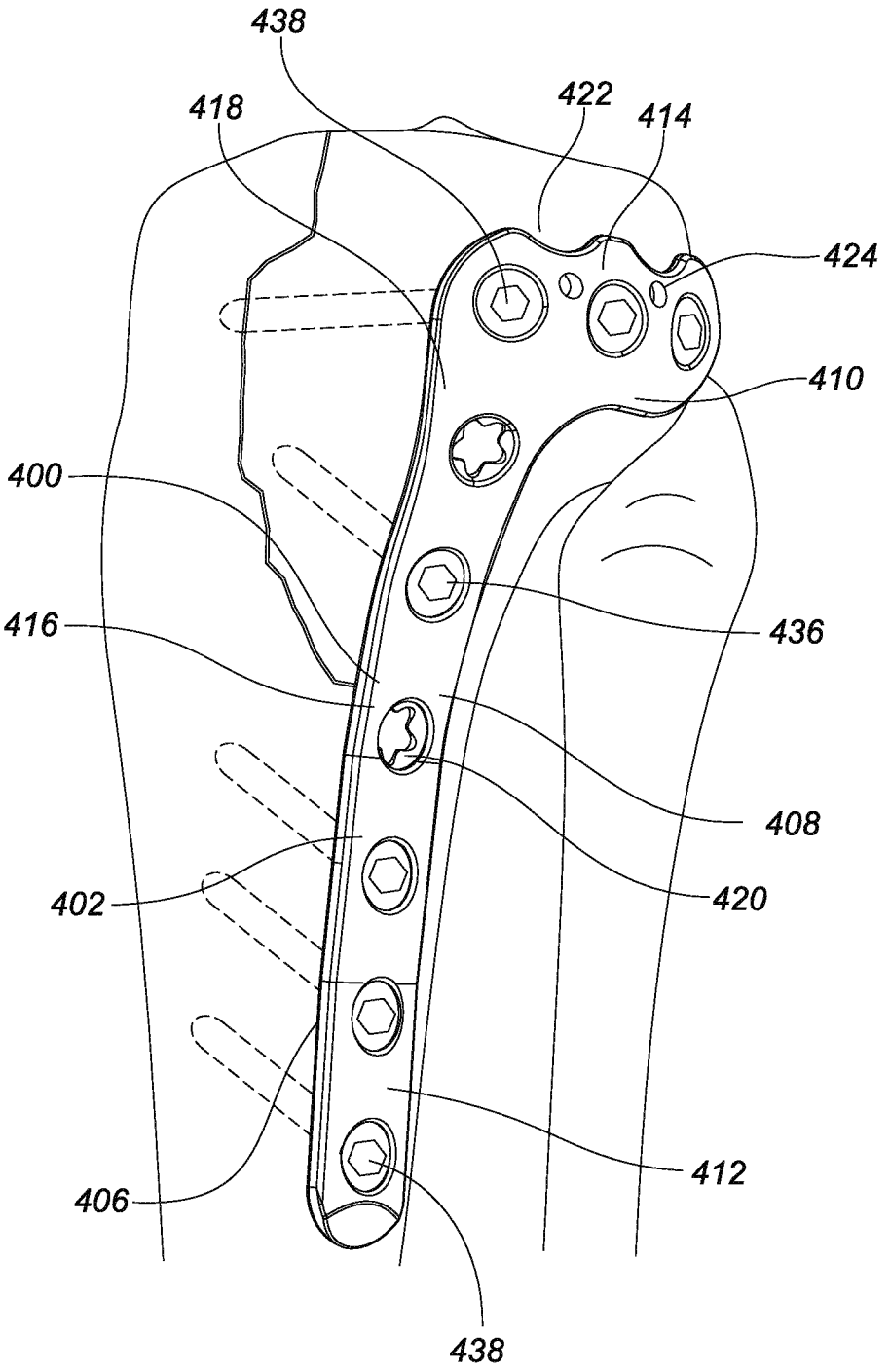


FIG. 39

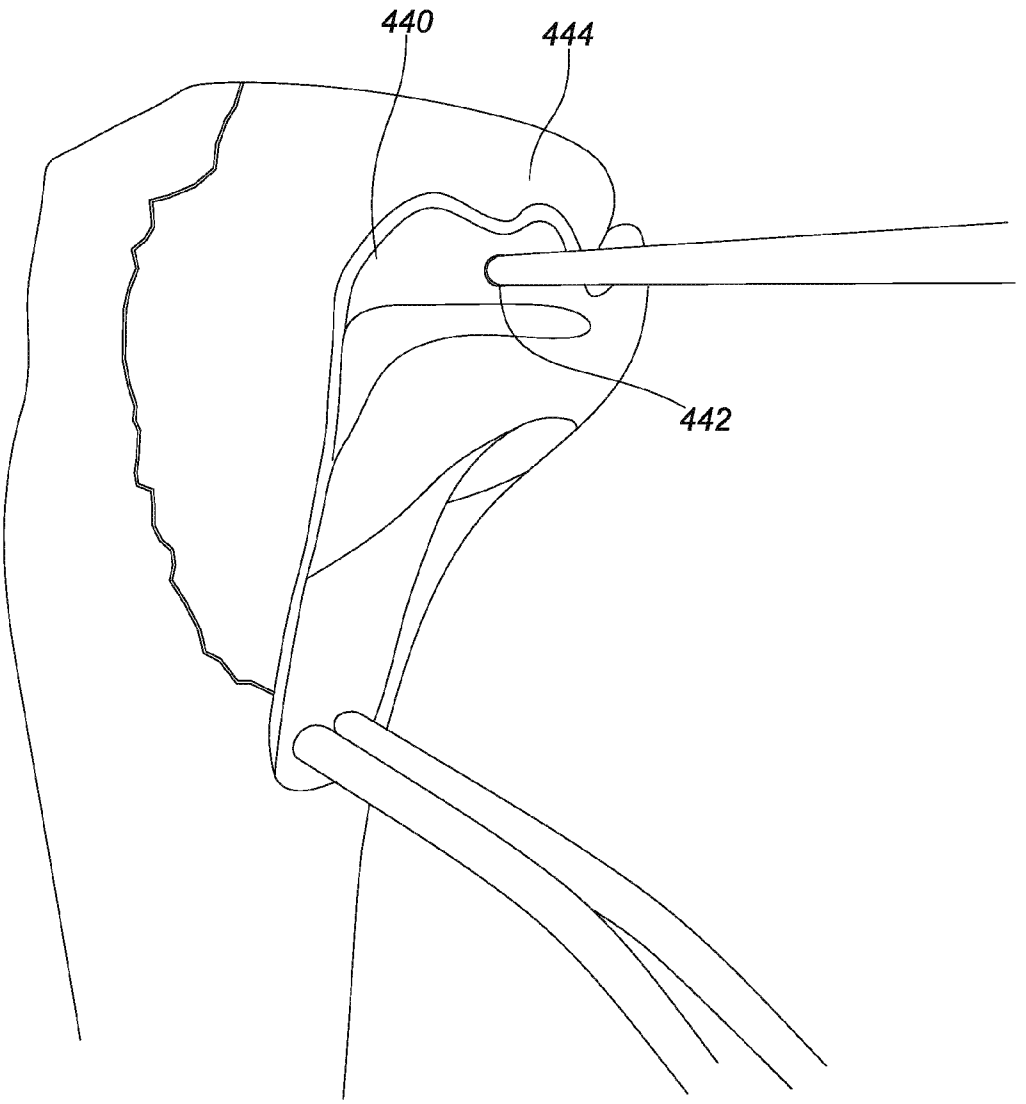


FIG. 40

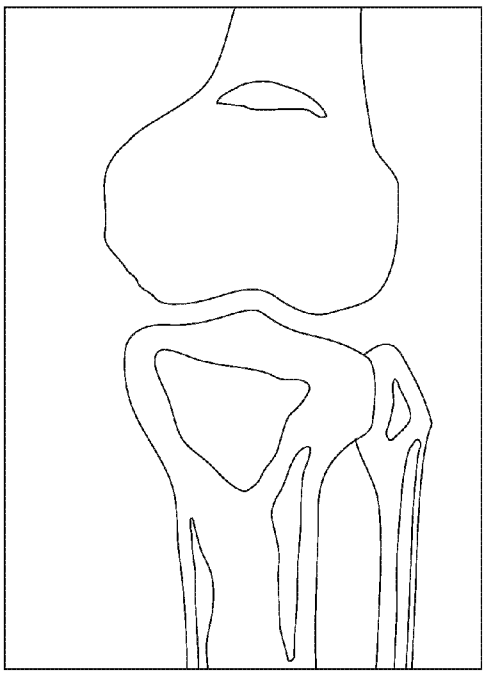


FIG. 41A

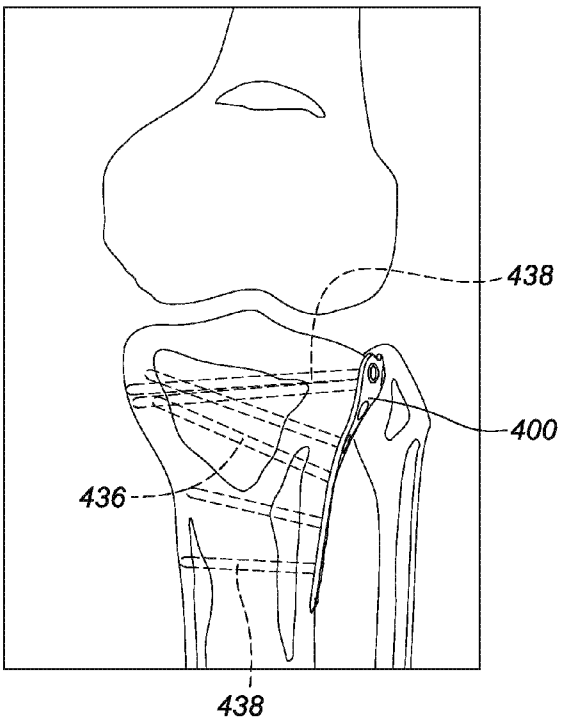


FIG. 41B

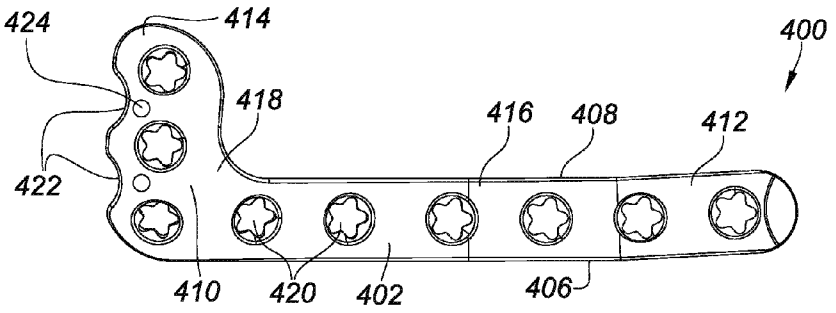


FIG. 42

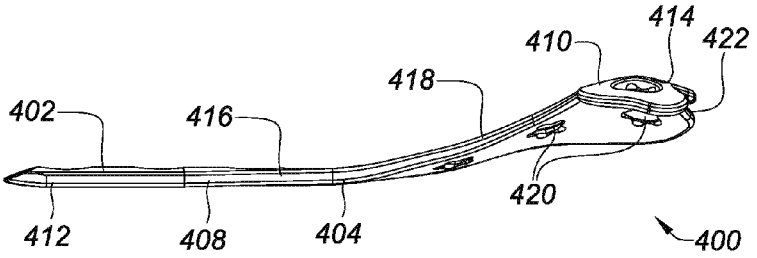


FIG. 45

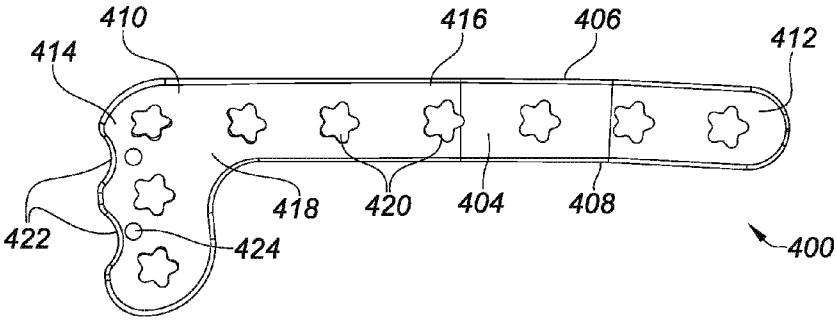


FIG. 43

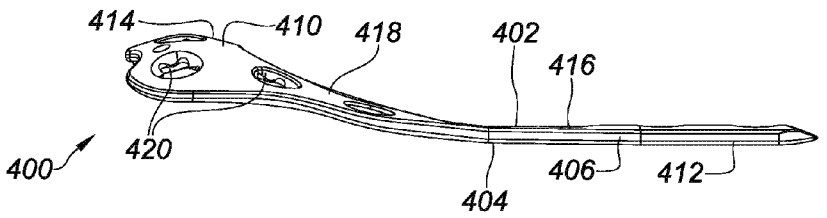


FIG. 44

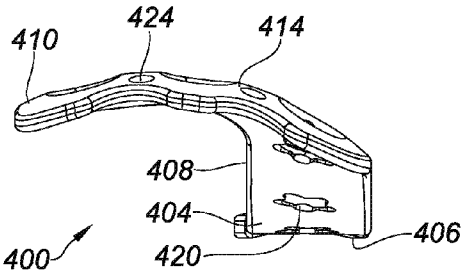


FIG. 46

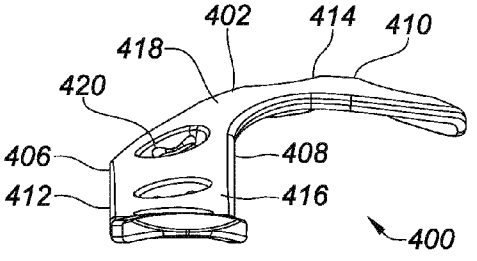


FIG. 47

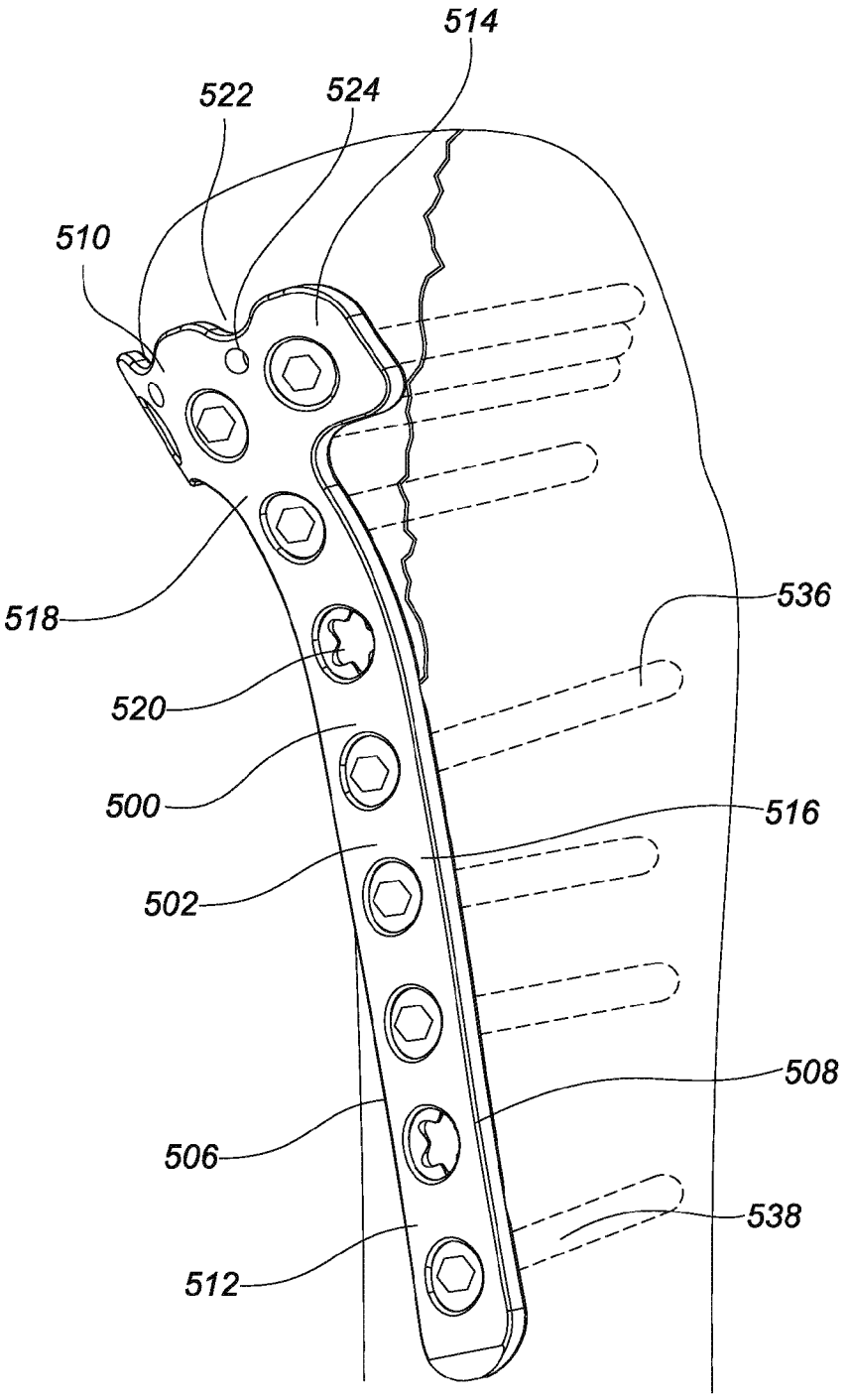


FIG. 48

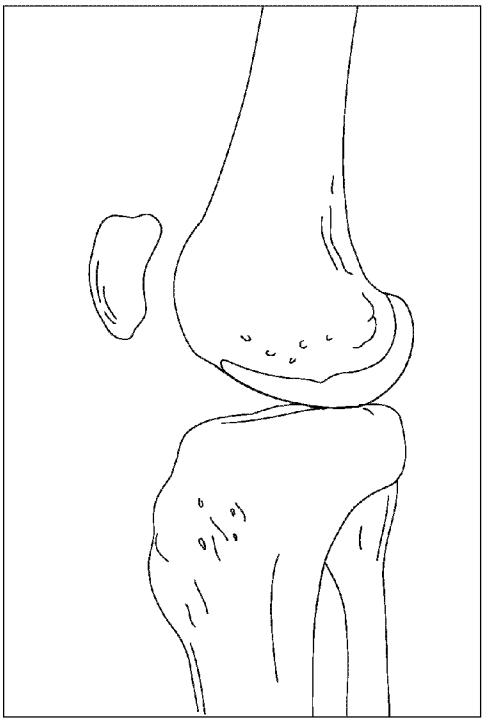


FIG. 49A

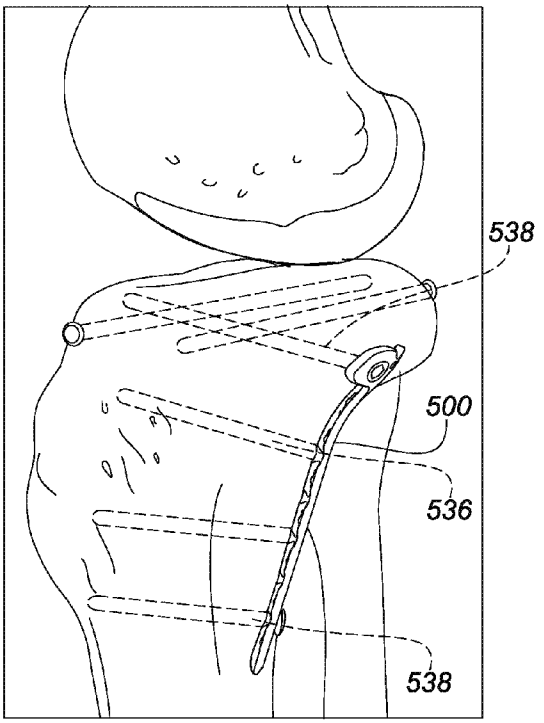


FIG. 49B

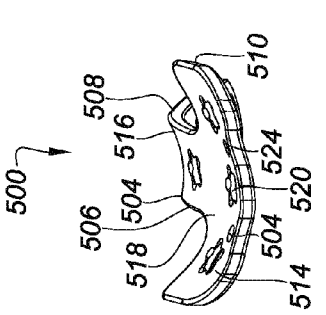


FIG. 54

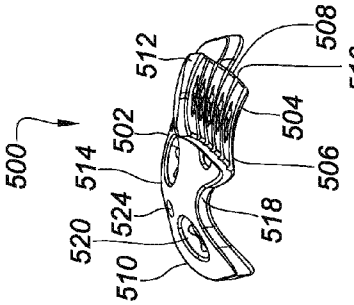


FIG. 55

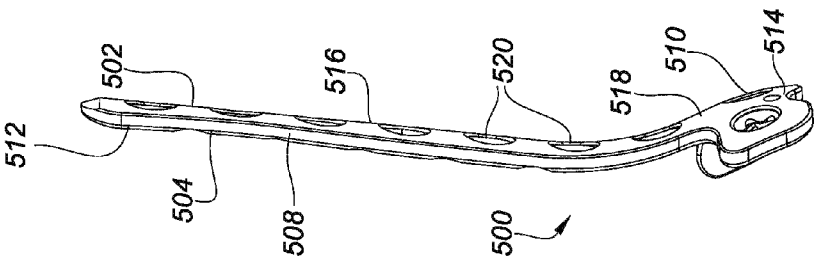


FIG. 53

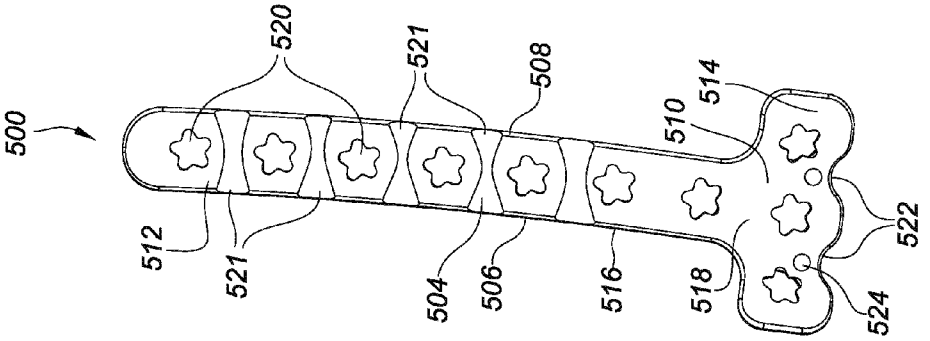


FIG. 51

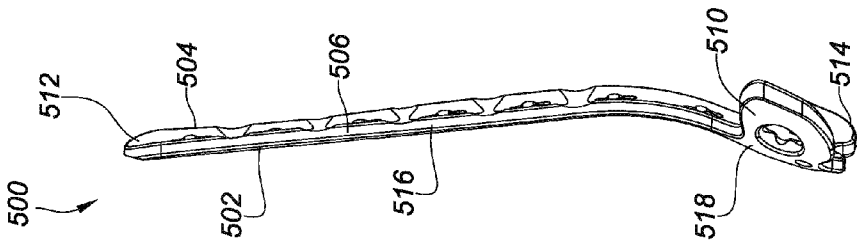


FIG. 52

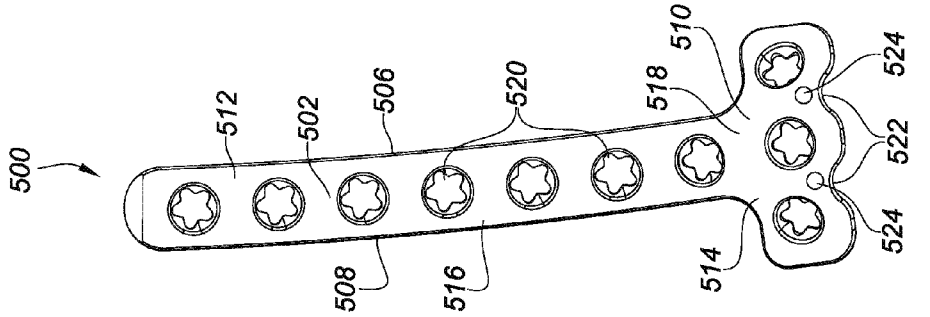


FIG. 50

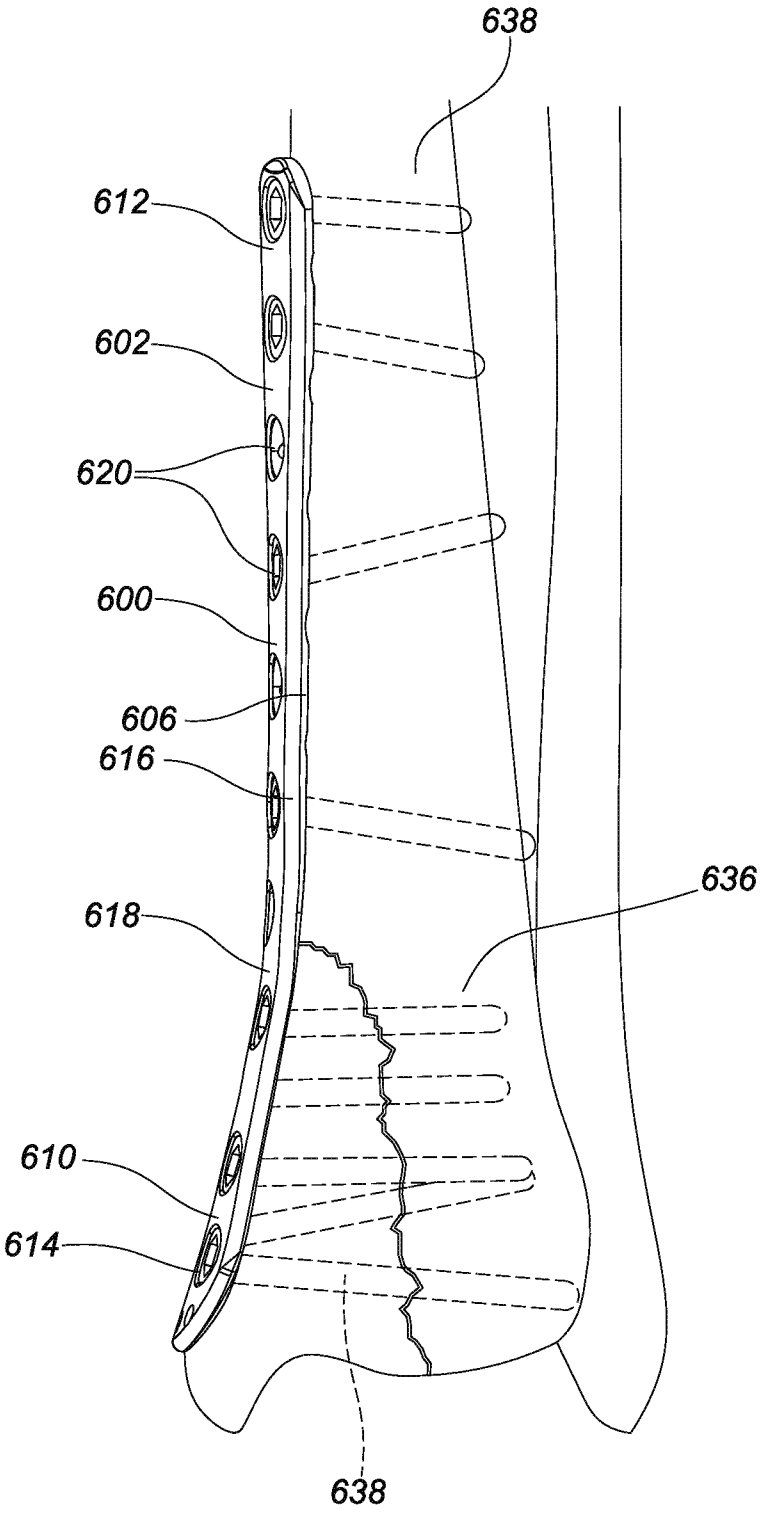


FIG. 56

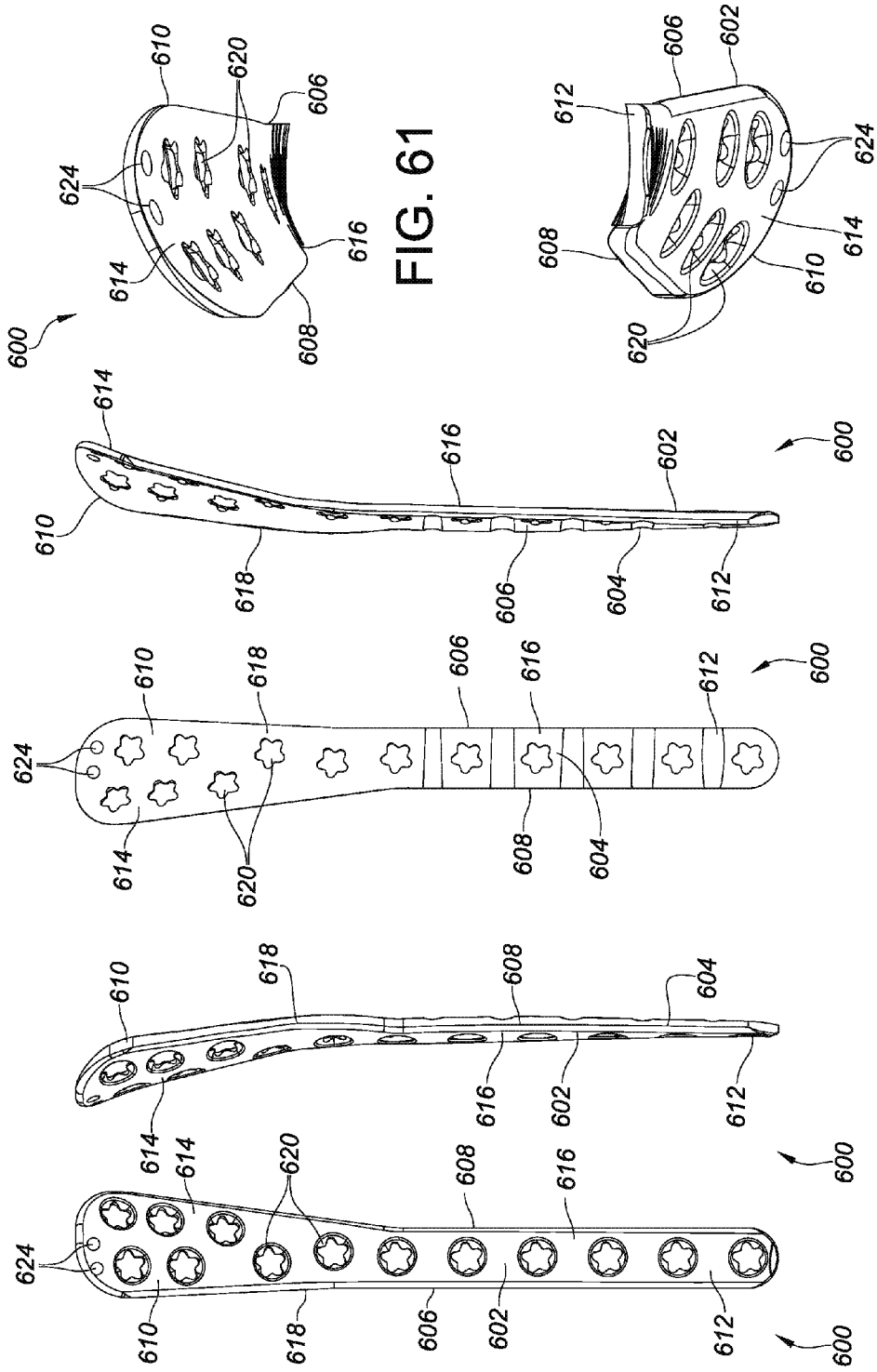


FIG. 57 FIG. 60 FIG. 58 FIG. 59 FIG. 62 FIG. 61

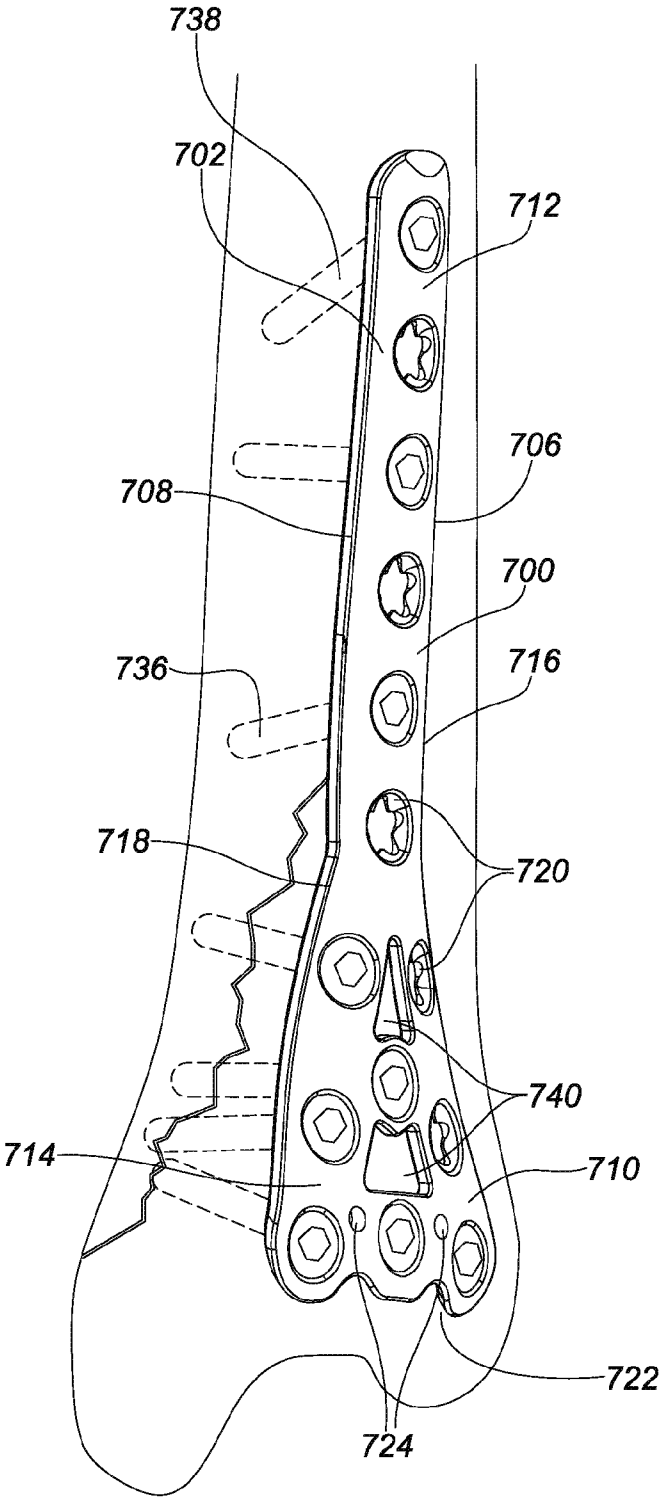


FIG. 63

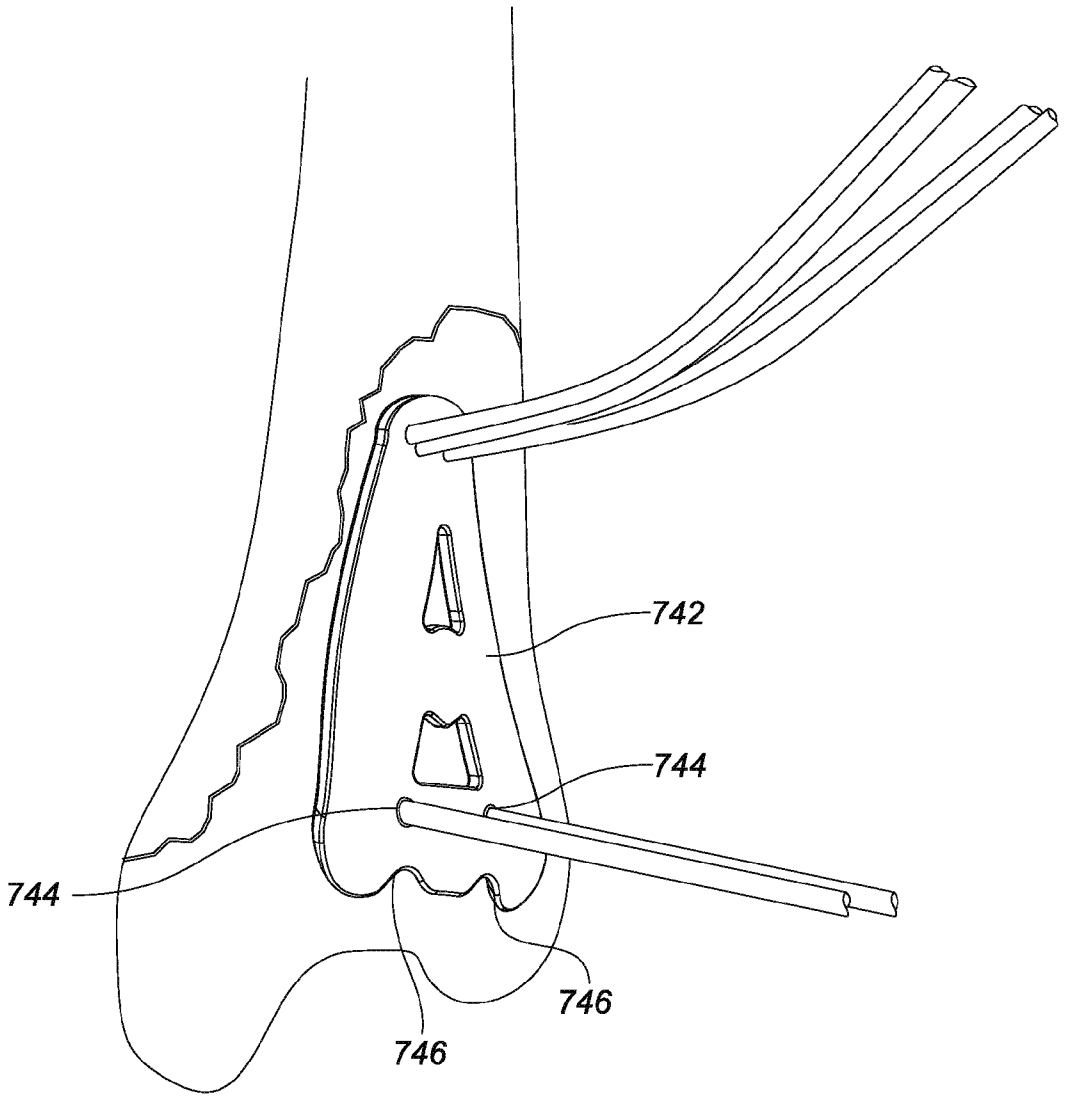


FIG. 64

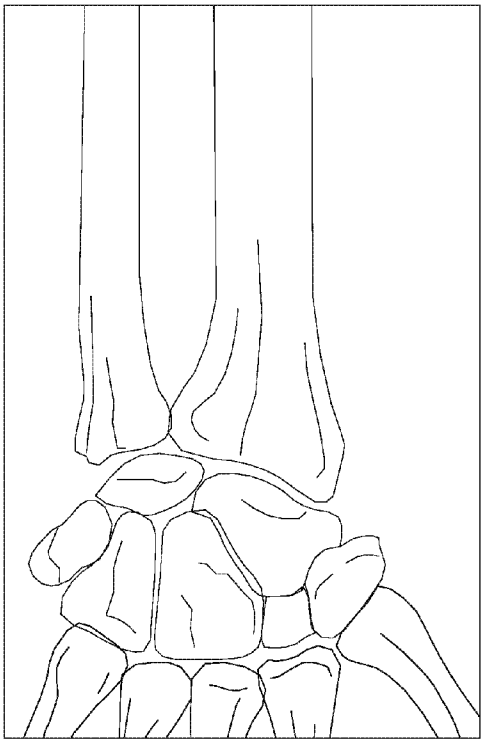


FIG. 65A

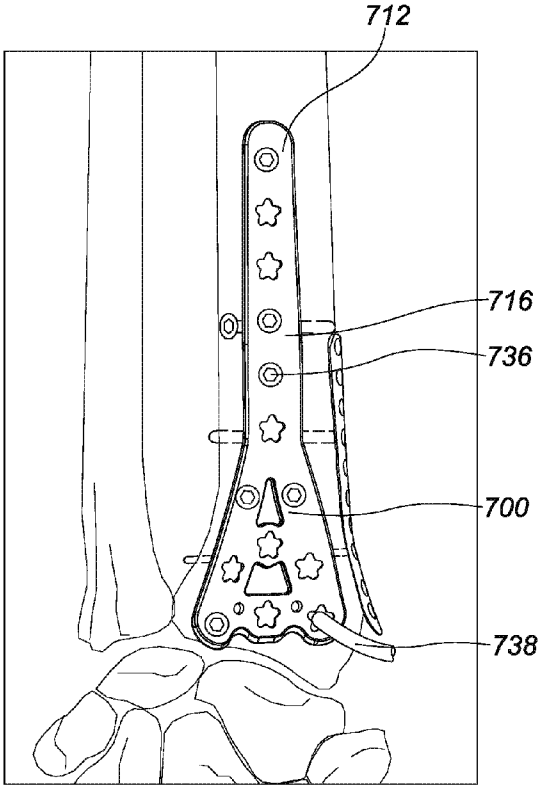


FIG. 65B

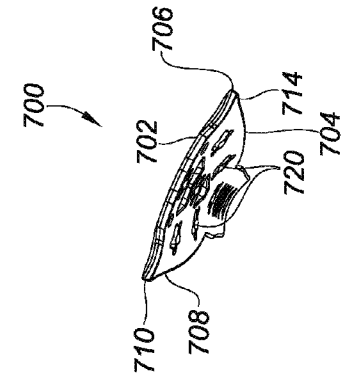


FIG. 70

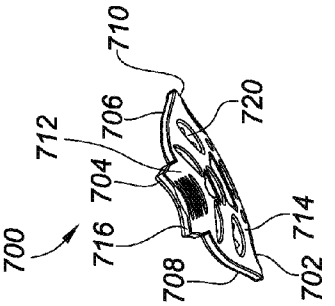


FIG. 71

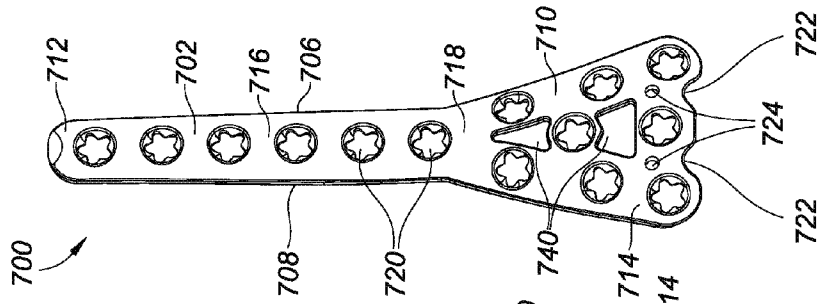


FIG. 66

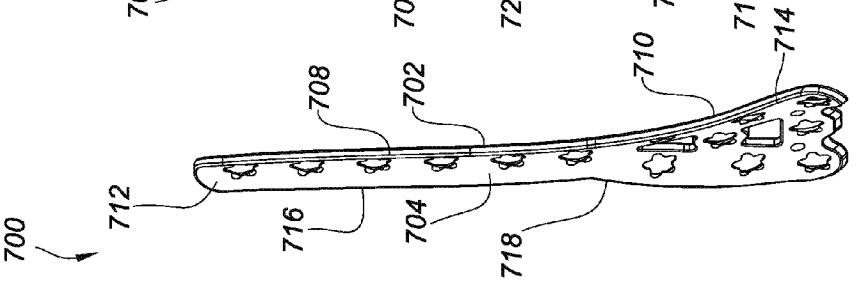


FIG. 69

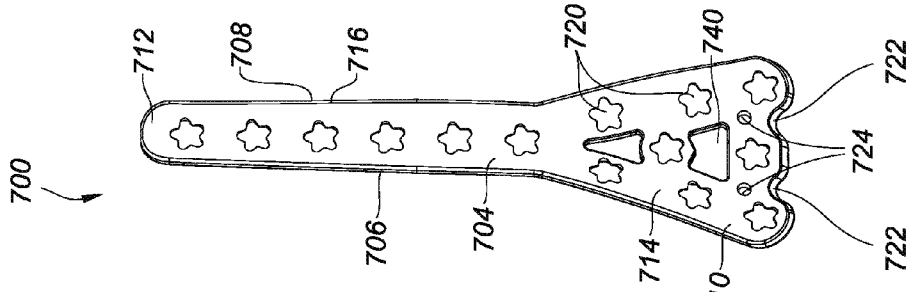


FIG. 67

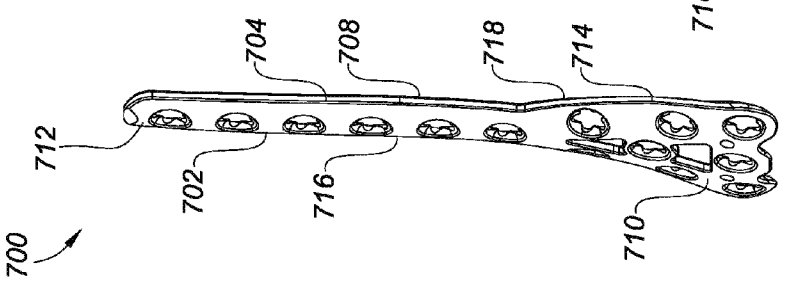


FIG. 68

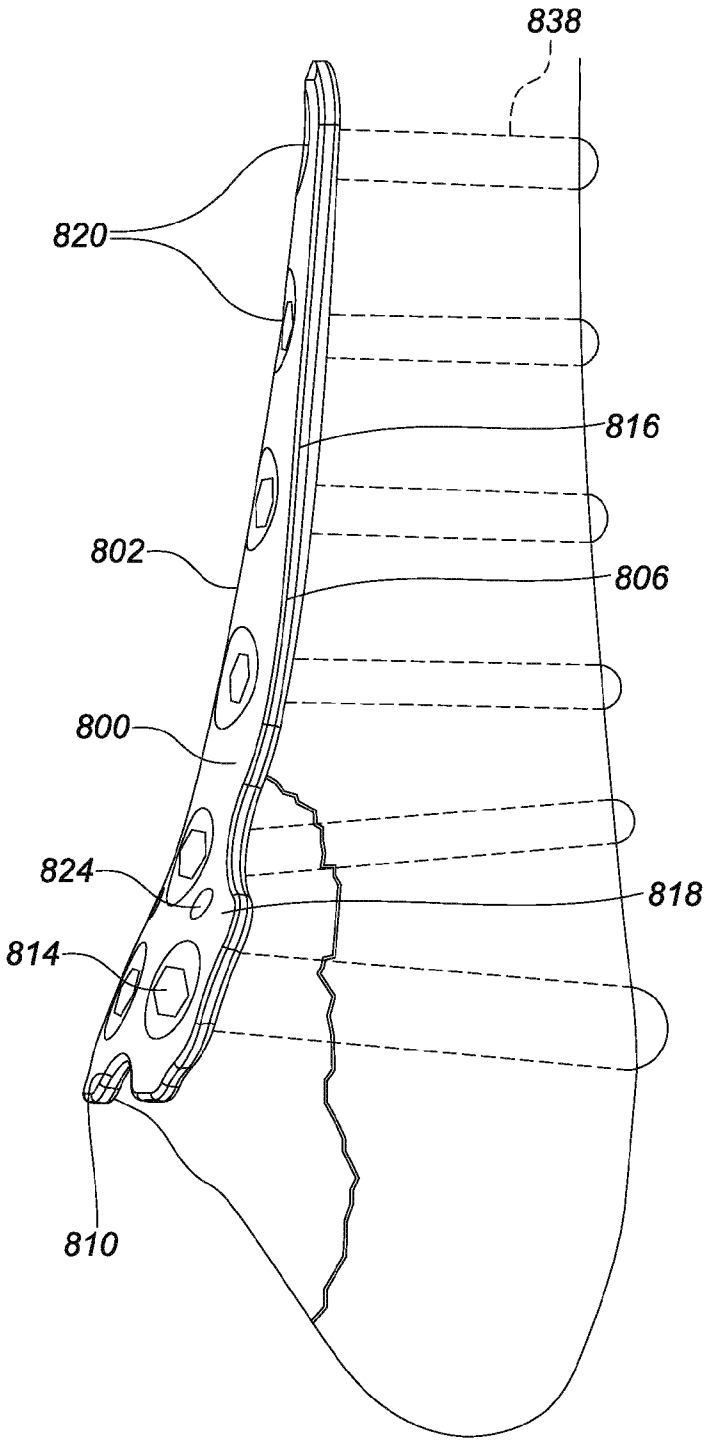


FIG. 72

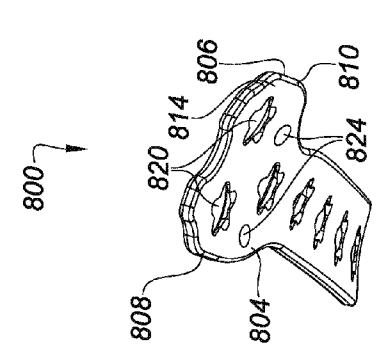


FIG. 77

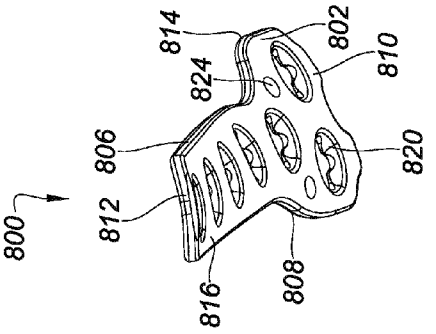


FIG. 78

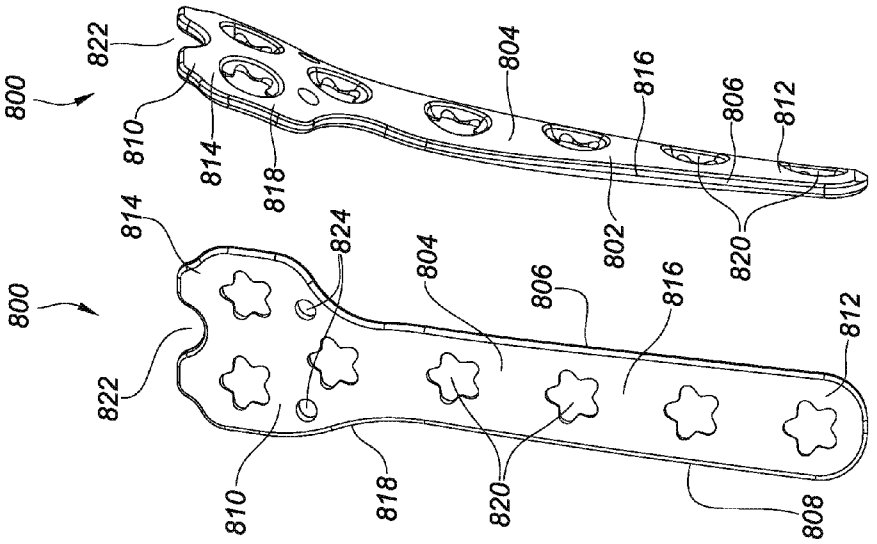


FIG. 75

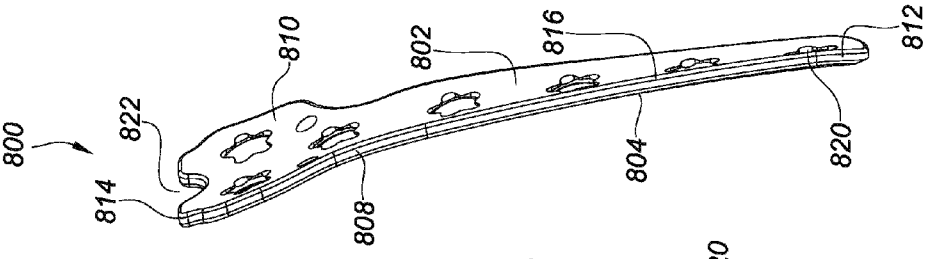


FIG. 76

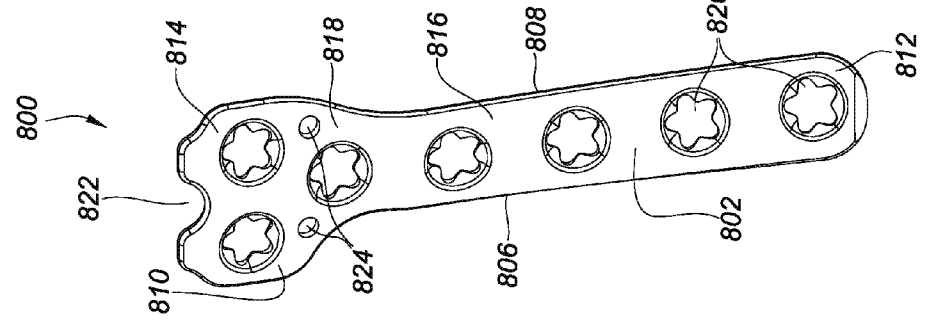


FIG. 73

FIG. 74

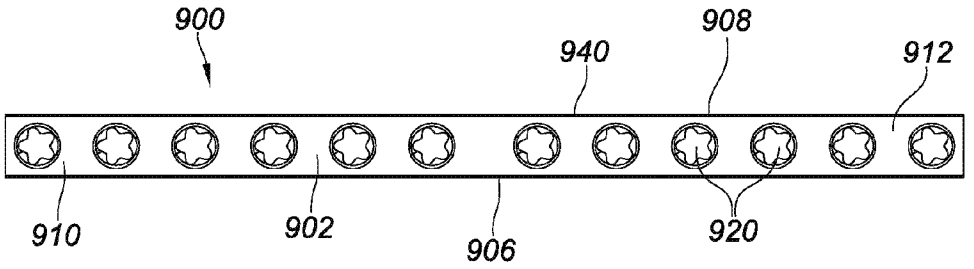


FIG. 79

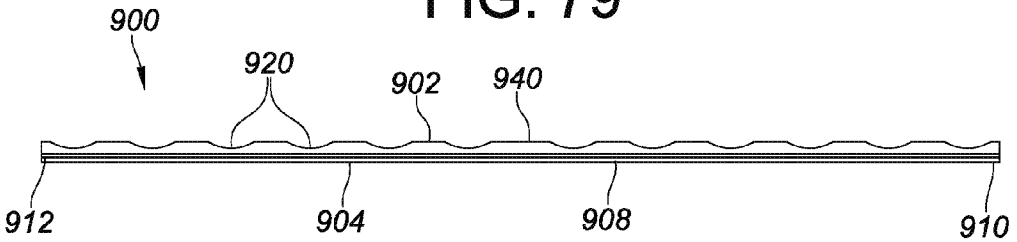


FIG. 82

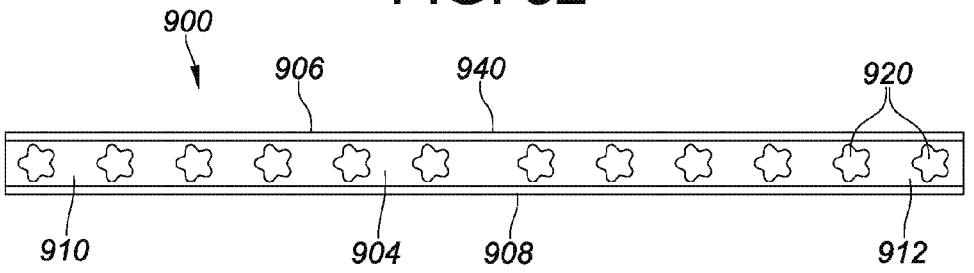


FIG. 80

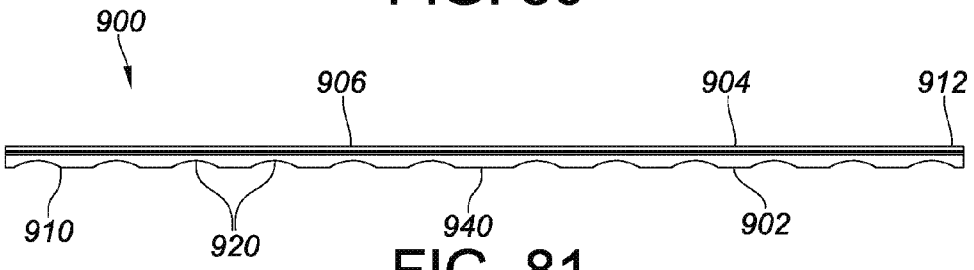


FIG. 81

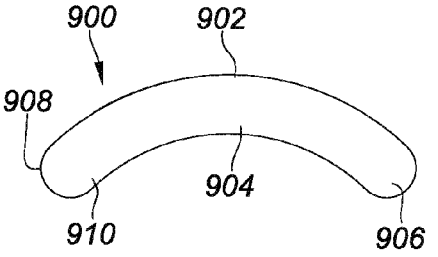


FIG. 83

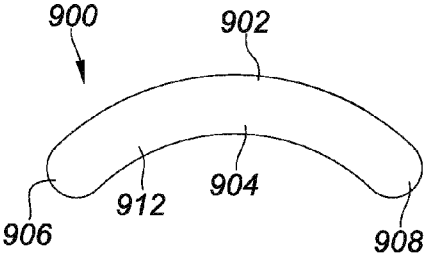


FIG. 84

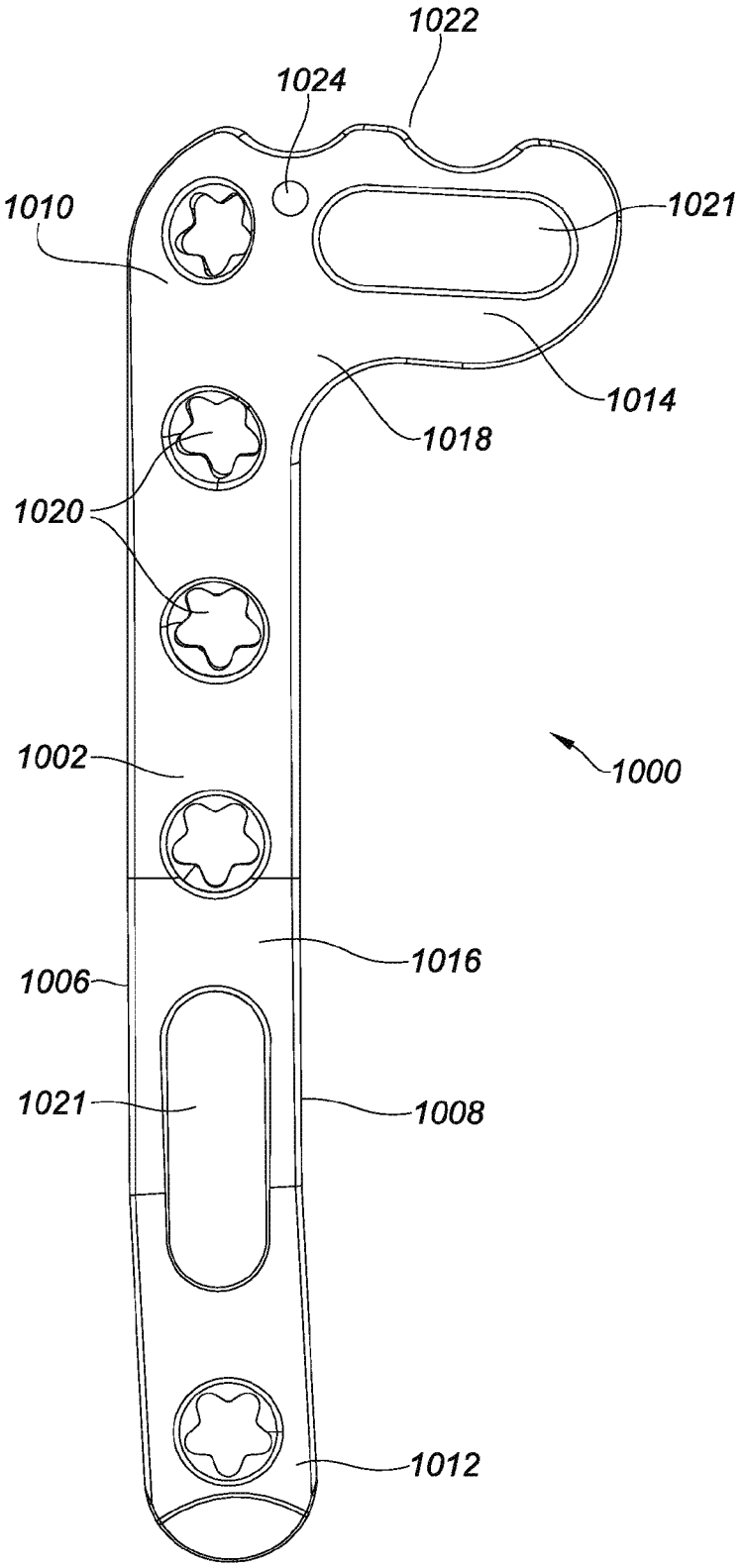

1022
1024
1010
1021
1014
1018
1020
1002
1000
1016
1006
1021
1008
1012

FIG. 85A

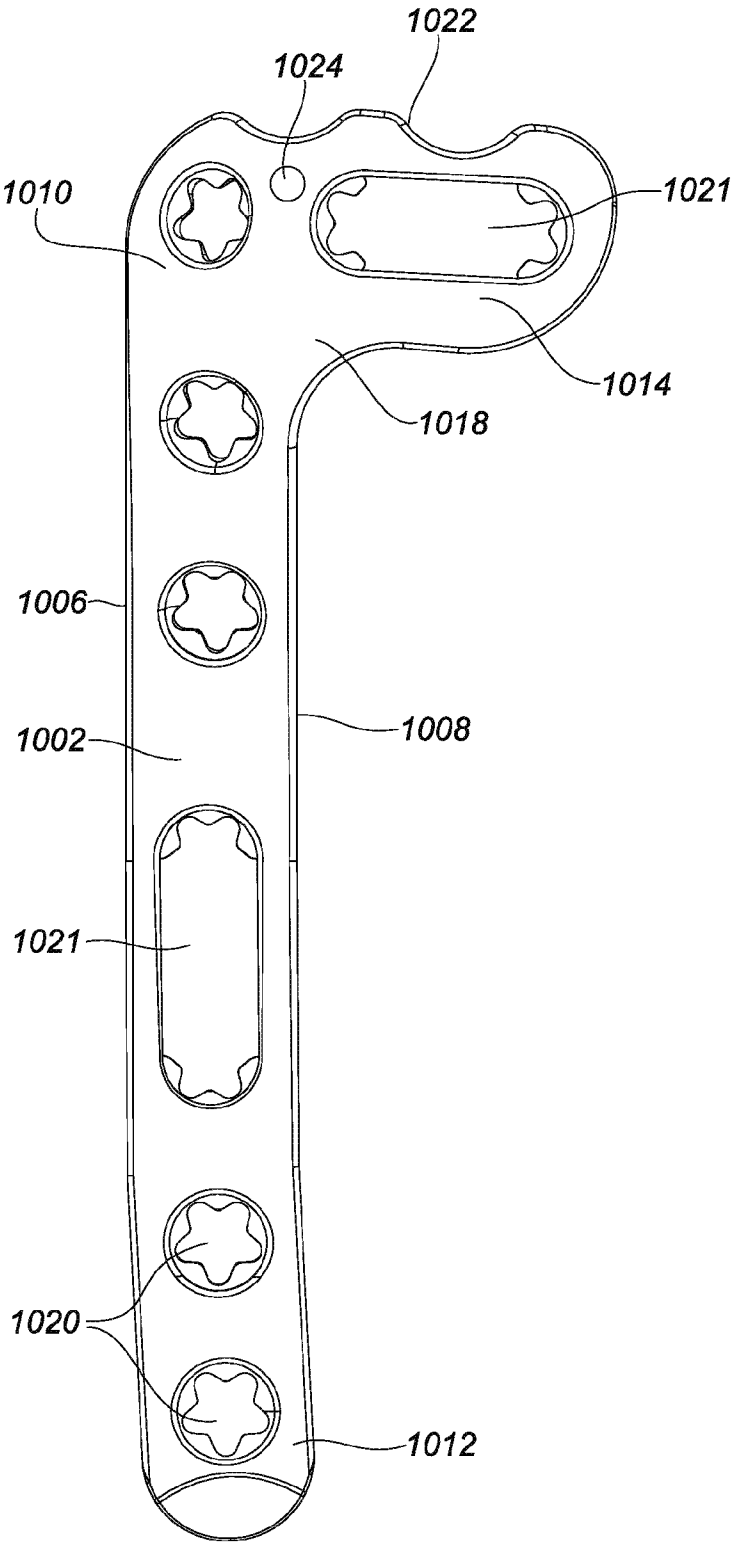


FIG. 85B

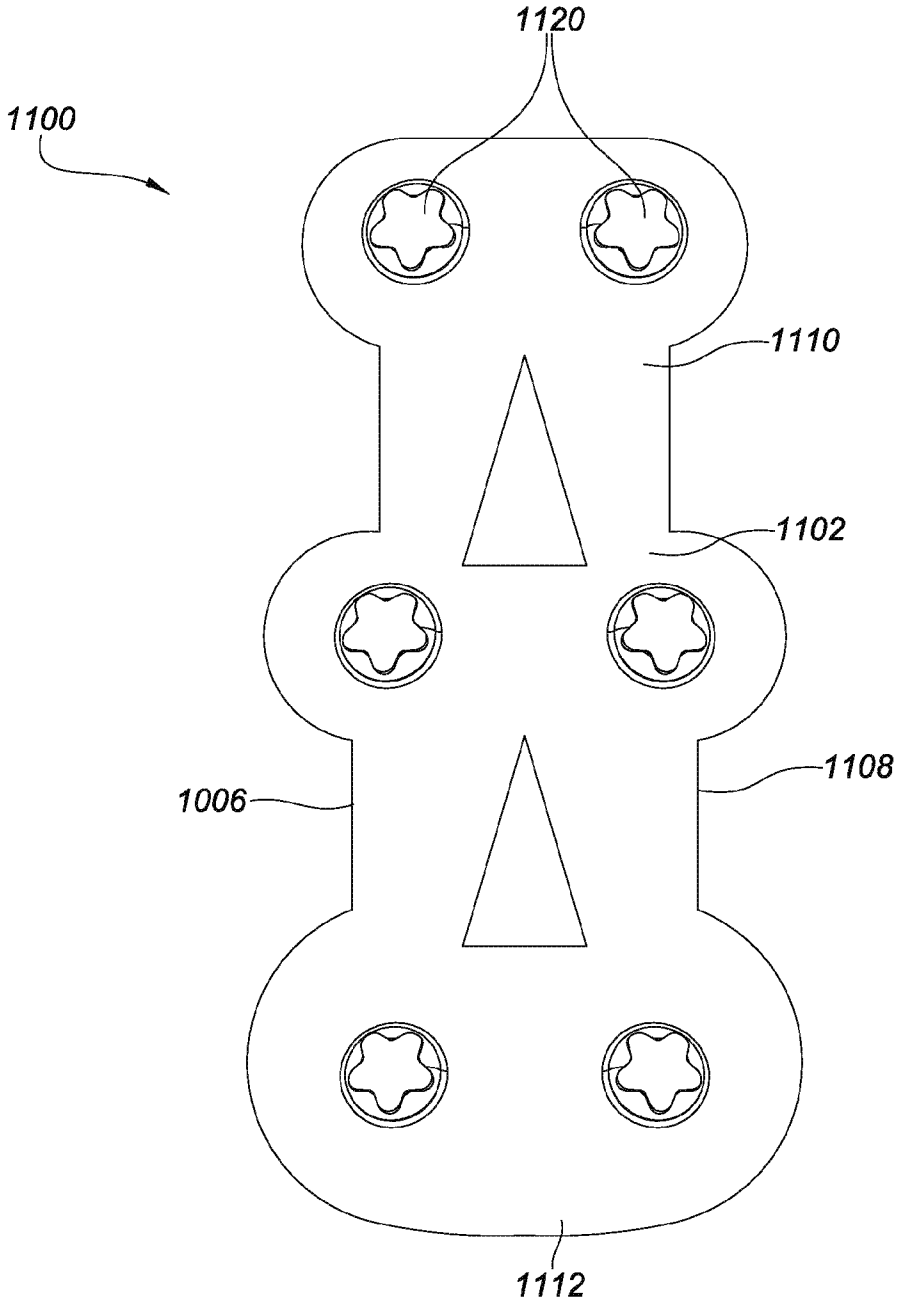


FIG. 86

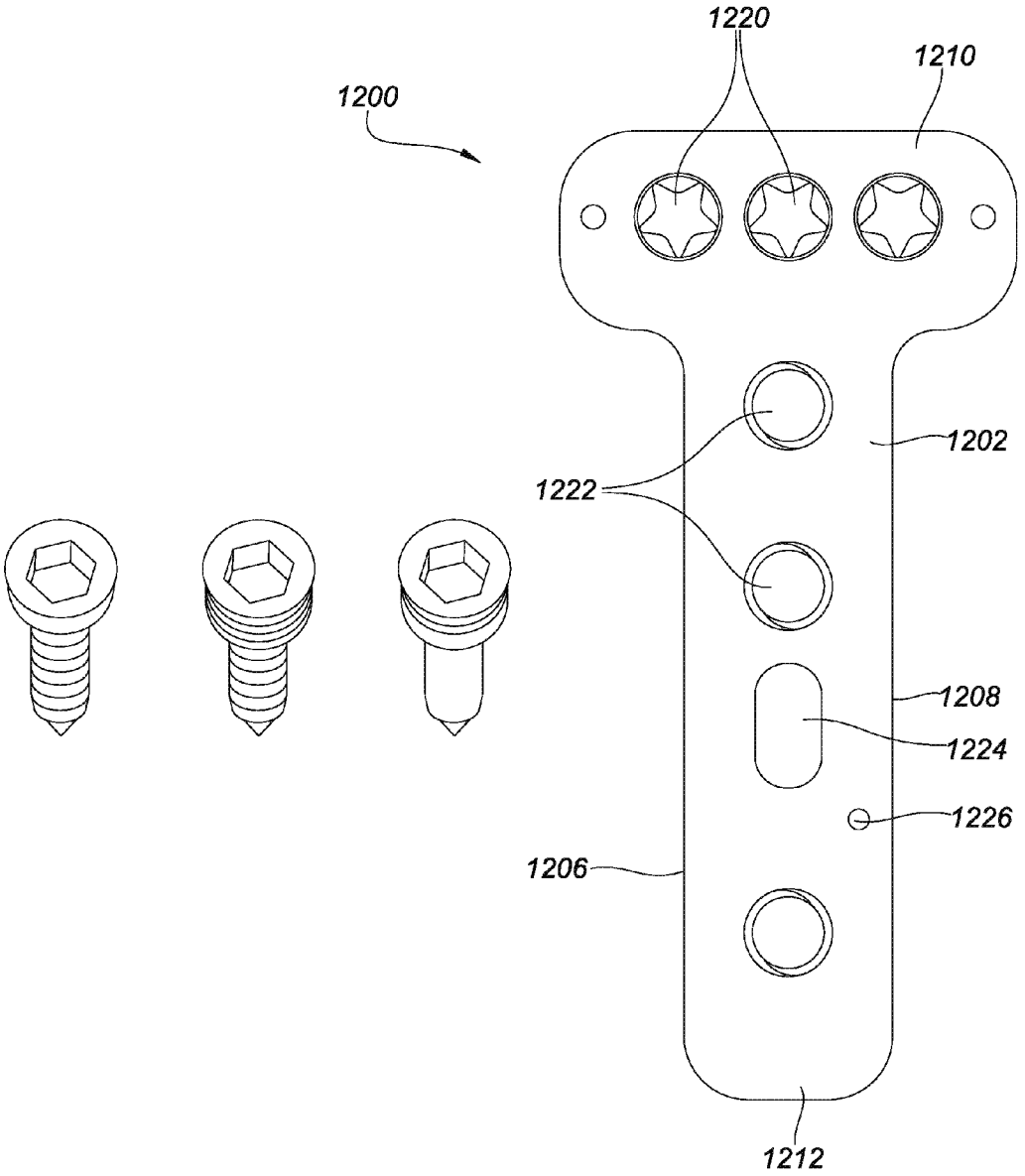


FIG. 87

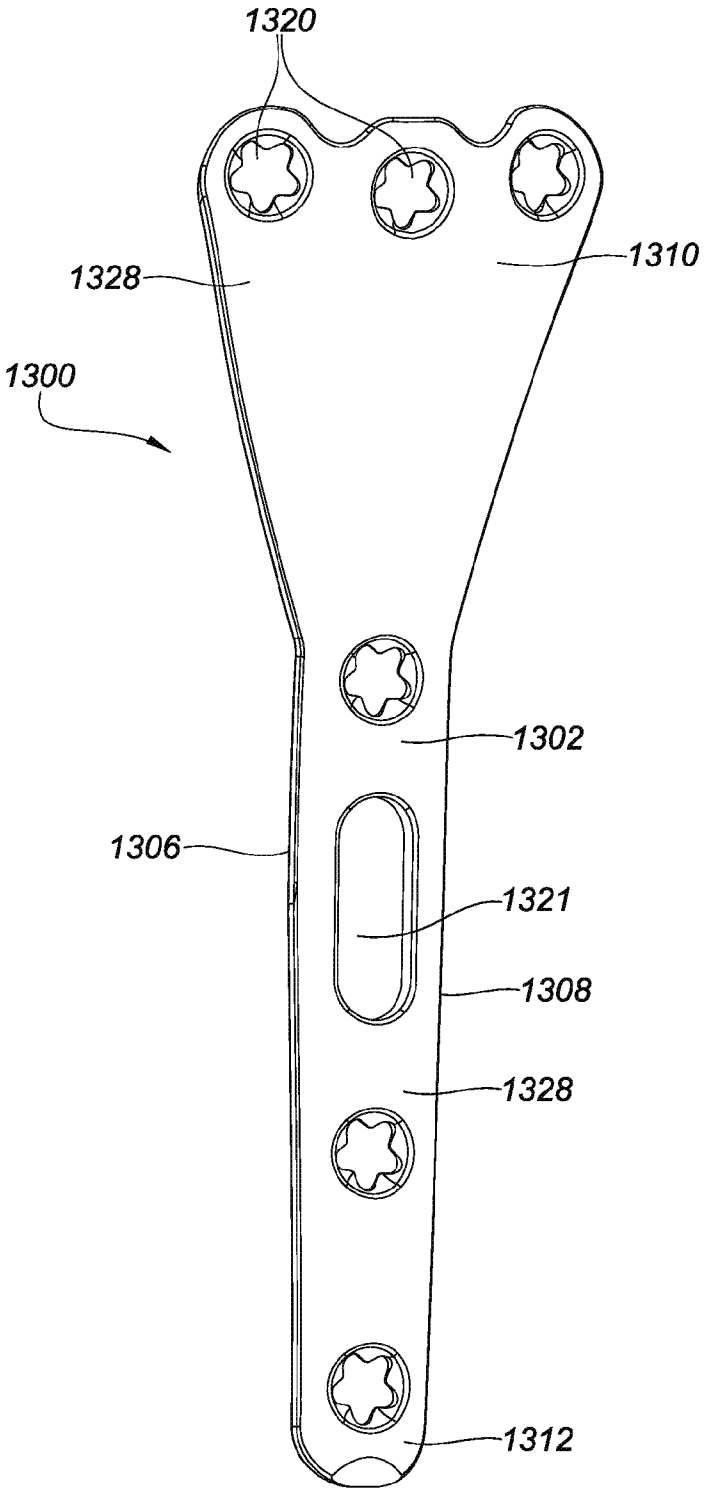


FIG. 88A

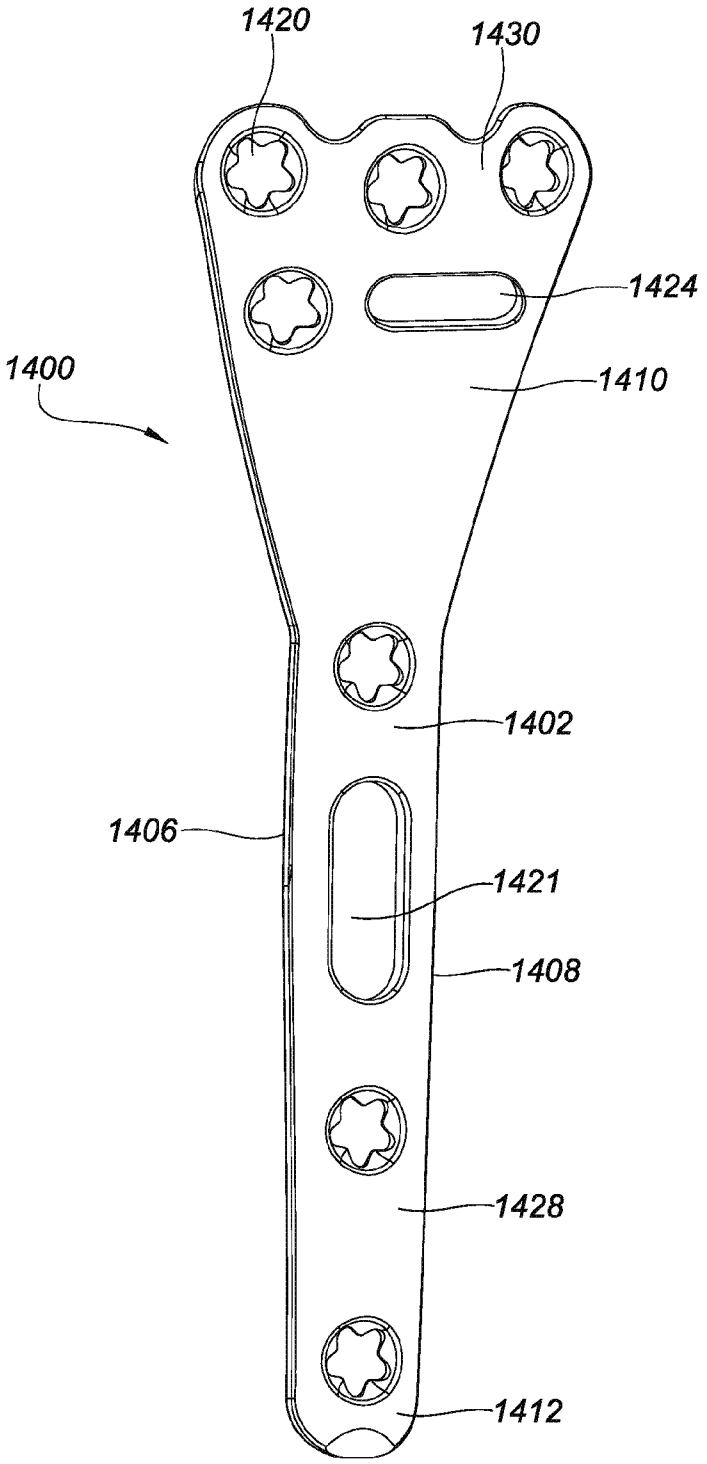


FIG. 88B

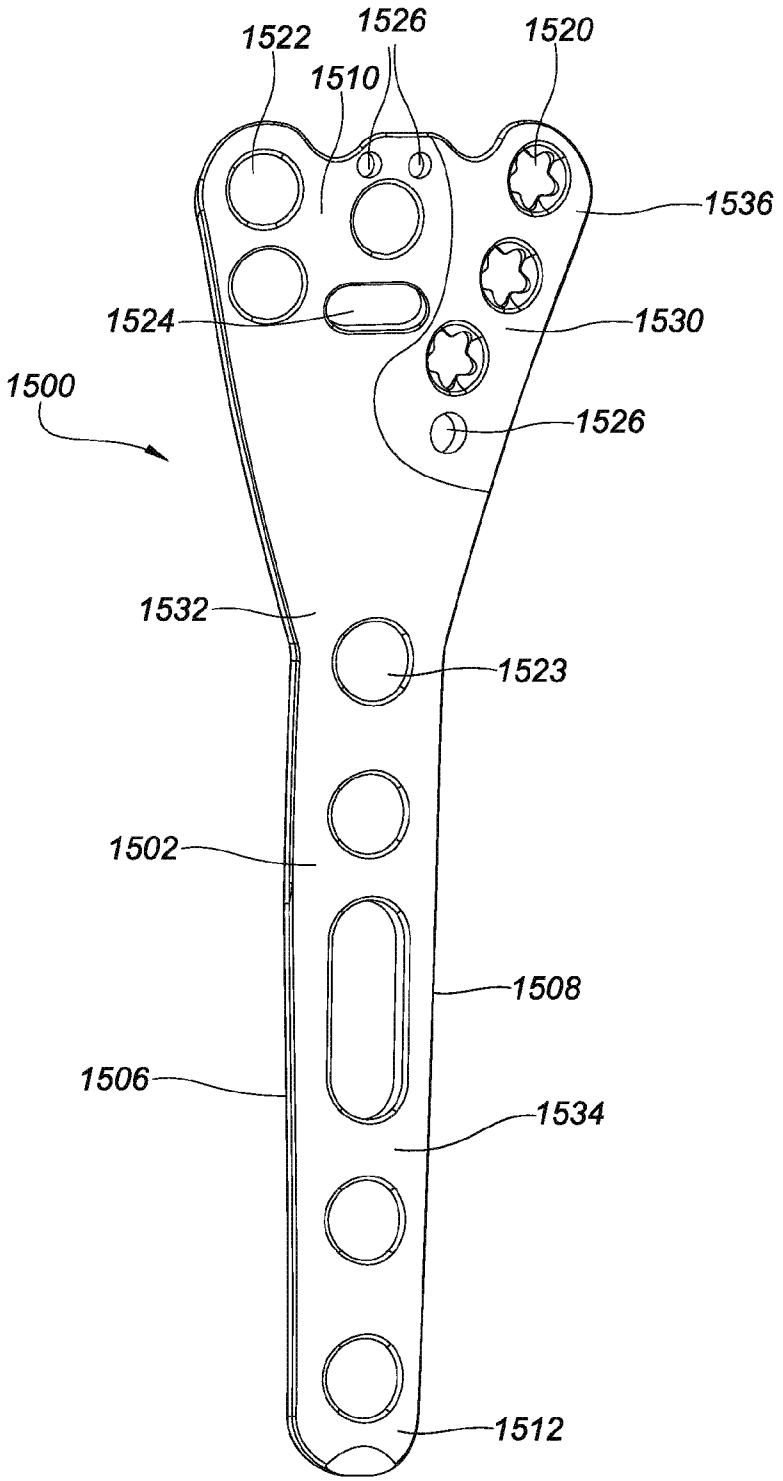

1522
1526
1520
1510
1536
1524
1530
1500
1526
1532
1523
1502
1508
1506
1534
1512

FIG. 89A

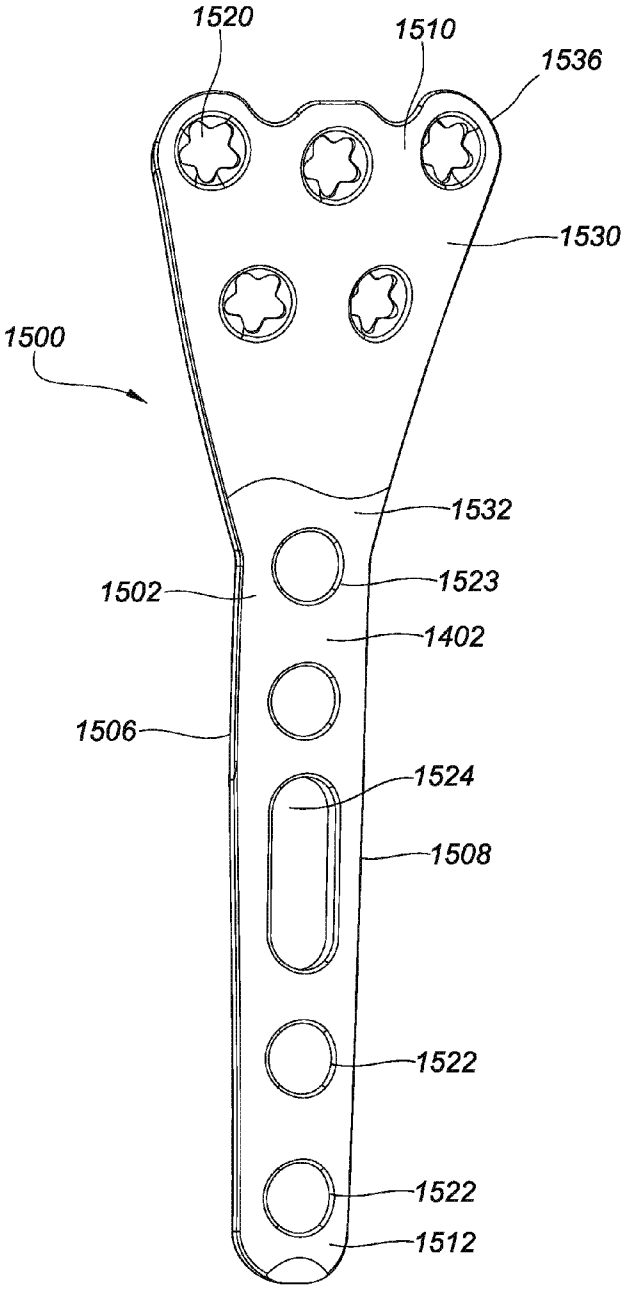


FIG. 89B

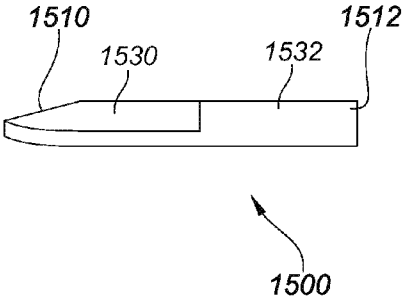


FIG. 89C

SYSTEMS AND METHODS FOR USING POLYAXIAL PLATES

This application is a continuation of U.S. patent application Ser. No. 12/069,331, filed Feb. 8, 2008, now allowed, which is a continuation-in-part of U.S. patent application Ser. No. 11/996,795 filed Jan. 25, 2008, which is the U.S. National Phase of International Application No. PCT/US2006/028778 filed Jul. 25, 2006, which claims the benefit of U.S. Provisional Application Ser. No. 60/702,231 filed Jul. 25, 2005 titled "Locking Screw," the entire contents of the prior applications are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

This invention relates generally to orthopedic fixation devices and bone plating systems for fracture fixation, and particularly to systems and methods for using bone plates that provide polyaxial fixation of fasteners.

Bone fractures are often repaired by securing a bone plate across the fracture. Depending upon which bone is to be treated, the bone plate may be straight or curved to match the contour of the bone for which it is designed. Bone plates may also be provided in many shapes and sizes. In cases where a bone is severely comminuted or if bone segments are missing, the use of bone plate and screw systems promotes healing of the fracture by providing a rigid fixation or support structure between the bone and the plate.

Bone plates may be secured to the bone in a number of ways. An existing solution is a plate and screw system where the screws are locked in the plate. A bone screw is threaded through an opening in the plate and into the bone. The screw is then secured to the bone plate via threads in the screw head that cooperate with threaded openings in the bone plate. This secures the plate with respect to the bone and provides rigid fixation because the relationship between the plate and screw(s) is fixed. Because the head of the locking screw interdigitates with threads in the plate, the plate and screws(s) form a stable system or construct, and the stability of the fracture can be dependent on or aided by the stiffness of the construct. Locking a screw into the plate can achieve angular and axial stability and eliminate the possibility for the screw to toggle, slide, or be dislodged, reducing the risk of postoperative loss of reduction.

However, although locking screws may reduce the incidence of loosening, they provide only one fixed angle relationship between the plate and the screw(s). The insertion angle is limited to a single direction because the threads of the head cooperate or mate with the threads of the hole in one direction only. The longitudinal axis of the screw lines up with the central axis of the hole, and no angular variation is allowed. In short, locking screws are unidirectional, limiting their use in some instances.

For example, when treating a severe fracture, fragments may be shattered and in irregular positions. Although a surgeon may wish to obtain the benefits of a locking screw and bone plate used together, the angle at which the locking screw extends from the plate at a certain opening may not be the angle that would allow the surgeon to "grab" (or seize, fix, or otherwise secure) the desired, random bone fragment. In this case, the surgeon may need to secure the plate to the bone somewhere else, or use a non-locking screw. Although non-locking screws do not lock into the plate, they can be inserted at various angles.

Specifically, non-locking screws are secured into bone in the same way that locking screws are, but they are not secured to the plate. Their heads are typically rounded where they

contact the bone plate. Thus, one advantage of non-locking screws is that they can be inserted at various angles because they are not limited by the thread-to-thread contact of locking screws with the bone plate. However, if the surgeon desires the rigid stable construct of a locking screw and plate, the use of a non-locking screw to obtain the desired angular orientation is not necessarily optimal.

There have been bone plating systems developed that provide the surgeon with the option of choosing a non-locking or a locking screw. In some embodiments, these systems provide plates with some threaded holes (that may receive with either locking screws or non-locking screws) and some non-threaded holes (for non-locking screws). There are also systems that provide partially threaded slots to allow either non-locking or locking screws to be used together. Such combination slots provide surgeons with the intraoperative choice about whether to use the plate with locking screws, non-locking screws, or with a combination of both. These combination slots typically have a partially threaded opening that can receive either a compression screw or a locking screw. However, because these combination slots are only partially threaded, the locking screw(s) may not be able to maintain the fixed angular relationship between the screw(s) and plate under physiological loads. Specifically, the locking screws within the plate are only partially captured and thus only partially surrounded by threads. Under high stress and loading conditions, the slot may distort and allow the fixed angular relationship between the locking screw and plate to change. This can result in loss of fixation or loss of established intraoperative plate orientation. Moreover, the locking screw can still only be inserted at a single angle—the predetermined angle defined by the manufacturer.

Additionally, current bone plate and screw systems still limit a surgeon's ability to both (a) lock a fastener with respect to the bone plate, but still (b) allow the fastener to extend from the bone plate at various angles. Locking screws lock into the plate, but only in a single angular configuration, and non-locking screws allow various angle configurations, but they do not provide a stable construct with the plate. Accordingly, none of these options allow a surgeon to capture bone fragments that do not fall in line with the axis of the opening provided on the plate in a rigid fashion. An example of this problem is shown in FIG. **21**. Thus, currently available options can still lead to malalignment and poor clinical results.

There have, however, been some attempts to provide polyaxial locking systems. For example, one effort includes providing holes that accept fixed angle locking pegs and multidirectional locking pegs, with a threaded cap inserted over the multidirectional peg to hold it into place. Such a system can be cumbersome to use because although the multidirectional peg can be inserted at any angle, the surgeon then needs to thread a small cap onto the top of the peg head and into the plate, requiring an extra step, extra time, and extra instrumentation. Such systems also fail to allow the use of non-locking members in conjunction with the locking and multidirectional pegs.

Other systems that have attempted to offer polyaxial fixation include providing a bone plate with inserts at the hole peripheries made out of a deformable material, with the remaining part of the plate made of titanium. The plate is manufactured and the inserts are then pushed into the hole peripheries and engaged in place by deformation and pressure. When screws are inserted, the inserts deform and are compressed between the edges of the holes of the plate, which holds the screws and inserts in place. Challenges with such systems are that they cannot be used with non-locking screws,

the inserts do not have the strength to receive and hold a regular locking screw, (i.e., they do not provide the surgeon with options), and plates with deformable inserts are more expensive to manufacture than regular bone plates. Other attempts have failed to provide adequate locking mechanisms.

Another attempt at polyaxial fixation includes a plate with holes that have an internal jacket with recesses that extend away from the axis of the hole or into the internal jacket surface. This attempt is described in International Application WO 2005/018472, titled Bone Plate. The internal jacket surface of the plate described in that application is threaded or has ribs or protuberances. A bone screw is intended to be pulled into the hole of the plate by the internal jacket surface. If the bone screw head is threaded, when the screw in inclined, the threaded head is intended to "jump over" the pitches of the threads in the hole of the plate interrupted by the recesses, without "cutting through" them. The goal of the invention is to provide a bone plate that can have bone screws introduced at an angle that is different from the specified axis of the hole and secured into position.

It would be beneficial to provide plates and methods that combine polyaxial locking fixation with a thinner profile and enhanced bone contouring. Such plates could be useful in fixation of partial articular and/or non full body weight bearing fractures, where a more flexible plate that is more closely shaped in accordance with bone structure and that features polyaxial locking openings could provide additional options for the surgeon. Such features could, if desired, but not necessarily, provide plates that allow compression of a mid portion against bone to create a buttress effect while other portions of the plate are locked to the bone using polyaxial fixation. Such plates could also be used without buttressing effects, but in a more conventional reinforcement mode. Other features could be combined with any or all of these features.

SUMMARY OF THE INVENTION

Certain embodiments of the invention provide plates for periarticular fractures or other non full body weight bearing applications that combine polyaxial fixation with a thinner profile and contouring that more closely conforms to bone. Such plates can be designed to achieve buttressing effect and/or to be used in a reinforcement mode. Other features can be combined with these. Such plates can be created for use on portions of the tibia, fibula, metatarsals, calcaneous, other ankle and foot bones, humerus, radius, ulna, spinal, maxillofacial, and other bones.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** shows a perspective view of a bone plate having fins according to one embodiment of the invention with a fastener inserted therein.

FIG. **2** shows a top perspective view of an opening in a bone plate according to one embodiment of the invention.

FIG. **3** shows a top view of a bone plate having multiple openings, with a fastener inserted therein.

FIG. **4** shows an underneath view of the bone plate of FIG. **3**.

FIG. **5** shows a side perspective view of a bone plate with fasteners inserted therein to illustrate a few of the multiple angles at which the plate can receive a fastener.

FIG. **6** shows an example of a fastener for use with various bone plates described herein.

FIG. **7** shows a top plan view of an alternate embodiment of an opening in a bone plate.

FIG. **8** shows a perspective view of the bone plate of FIG. **7**.

FIG. **9** shows a top plan view of a further embodiment of an opening in a bone plate.

FIG. **10** shows a perspective view of the bone plate of FIG. **9**.

FIGS. **11-15** show alternate shapes and types of bone plates that may be used with various embodiments of this invention.

FIG. **16** shows a cross-section view of an alternate embodiment having a finned fastener in place in a bone plate.

FIG. **17** shows a side perspective view of a fastener having a finned head according to one embodiment of the invention.

FIG. **18** shows a top perspective view of the fastener of FIG. **17**.

FIG. **19** shows a top perspective view of a bone plate that may be used to receive the fastener of FIGS. **17** and **18**.

FIG. **20** shows a cross-section of the threads of the plate of FIG. **19**.

FIG. **21***a* shows an example of a fracture that may be treated with various embodiments of the invention.

FIG. **21***b* is a schematic diagram that shows aspects of a buttressing effect achieved by certain plates according to certain embodiments of the invention.

FIGS. **22***a* and **22***b* are schematic drawings which show types of fractures that can be treated with plates according to certain embodiments of the invention.

FIG. **23** is a posterior view of a portion of a tibia and fibula with an installed lateral distal fibula plate according to one embodiment of the invention.

FIGS. **24***a* and **24***b* are radiographs showing an installed plate according to FIG. **23** and the bone in which it is installed.

FIG. **25***a* is a top view of the plate of FIG. **23**.

FIGS. **25***b* and *c* are a top plan view and a cross sectional view, respectively, of a tabbed opening according to one embodiment of the invention, as found for example in the plate of FIG. **23**.

FIG. **26** is a bottom view of the plate of FIG. **23**.

FIG. **27** is a left-side elevational view of the plate of FIG. **23**.

FIG. **28** is a right-side elevational view of the plate of FIG. **23**.

FIG. **29** is a head-end view of the plate of FIG. **23**.

FIG. **30** is a shaft end-view of the plate of FIG. **23**.

FIG. **31** is a lateral view of portions of a tibia and fibula with an installed posterolateral distal fibula plate according to an embodiment of the invention.

FIGS. **32***a* and **32***b* are radiographs of an installed plate of FIG. **31** and the bone in which it is installed.

FIG. **33** is a top view of the plate of FIG. **31**.

FIG. **34** is a bottom view of the plate of FIG. **31**.

FIG. **35** is a right-side elevational view of the plate of FIG. **31**.

FIG. **36** is a left-side elevational view of the plate of FIG. **31**.

FIG. **37** is a head-end view of the plate of FIG. **31**.

FIG. **38** is a shaft-end view of the plate of FIG. **31**.

FIG. **39** is a posterior view of portions of a tibia and fibula with an installed lateral proximal tibia plate according to one embodiment of the invention.

FIG. **40** is a posterior view of portions of a tibia with a lateral proximal tibial guide according to one embodiment of the invention.

FIGS. **41***a* and **41***b* are radiographs showing an installed plate of FIG. **39** and the bone in which it is installed.

FIG. **42** is a top view of the plate of FIG. **39**.

FIG. **43** is a bottom view of the plate of FIG. **39**.

FIG. **44** is a left-side elevational view of the plate of FIG. **39**.

FIG. **45** is a right-side elevational view of the plate of FIG. **39**.

FIG. **46** is a head-end view of the plate of FIG. **39**.

FIG. **47** is a shaft-end view of the plate of FIG. **39**.

FIG. **48** is a medial view of portions of a tibia with an installed posteromedial proximal tibial plate according to one embodiment of the invention.

FIGS. **49***a* and **49***b* are radiographs of the plate of FIG. **48** and the bone in which it is installed.

FIG. **50** is a top view of the plate of FIG. **48**.

FIG. **51** is a bottom view of the plate of FIG. **48**.

FIG. **52** is a left-side elevational view of the plate of FIG. **48**.

FIG. **53** is a right-side elevational view of the plate of FIG. **48**.

FIG. **54** is a head-end view of the plate of FIG. **48**.

FIG. **55** is a shaft-end view of the plate of FIG. **48**.

FIG. **56** is a view of portions of a tibia and fibula with an installed medial distal tibia plate according to one embodiment of the invention.

FIG. **57** is a top view of the plate of FIG. **56**.

FIG. **58** is a bottom view of the plate of FIG. **56**.

FIG. **59** is a left-side elevational view of the plate of FIG. **56**.

FIG. **60** is a right-side elevational view of the plate of FIG. **56**.

FIG. **61** is a head-end view of the plate of FIG. **56**.

FIG. **62** is a shaft-end view of the plate of FIG. **56**.

FIG. **63** is an anterior view of a portion of a tibia with an installed anterior distal tibial plate according to one embodiment of the invention.

FIG. **64** is an anterior view of a portion of a tibia with an anterior distal tibial guide according to one embodiment of the invention.

FIGS. **65***a* and **65***b* are radiographs of the anterior distal tibia plate of FIG. **63** and the bone in which it is installed.

FIG. **66** is a top view of the plate of FIG. **63**.

FIG. **67** is a bottom-view of the plate of FIG. **63**.

FIG. **68** is a right-side elevational view of the plate of FIG. **63**.

FIG. **69** is a left-side elevational view of the plate of FIG. **63**.

FIG. **70** is a head-end view of the plate of FIG. **63**.

FIG. **71** is a shaft-end view of the plate of FIG. **63**.

FIG. **72** is a medial view of a portion of a tibia with an installed posterior distal tibia plate according to one embodiment of the invention.

FIG. **73** is a top view of the plate of FIG. **72**.

FIG. **74** is a bottom view of the plate of FIG. **72**.

FIG. **75** is a right-side elevational view of the plate of FIG. **72**.

FIG. **76** is a left-side elevational view of the plate of FIG. **72**.

FIG. **77** is a head-end view of the plate of FIG. **72**.

FIG. **78** is a shaft-end view of the plate of FIG. **72**.

FIG. **79** is a top view of a tubular plate according to one embodiment of the invention.

FIG. **80** is a bottom view of the plate of FIG. **79**.

FIG. **81** is a left-side elevational view of the plate of FIG. **79**.

FIG. **82** is a right-side elevational view of the plate of FIG. **79**.

FIG. **83** is a head-end view of the plate of FIG. **79**.

FIG. **84** is a shaft-end view of the plate of FIG. **79**.

FIGS. **85***a* and *b* are views of low profile lateral proximal tibial plates according to one embodiment of the invention with slots or elongated openings.

FIG. **86** is a view of a low profile spine plate according to one embodiment of the invention.

FIG. **87** is a view of a low profile plate according to one embodiment of the invention that has multiple types of openings.

FIGS. **88***a* and *b* are views of low profile plates according to one embodiment of the invention that have a slot or elongated opening in the shaft.

FIGS. **89***a, b* and *c* are views of partial low profile—partial physiological load bearing plates according to one embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

I. Plates with Polyaxial Openings Generally

Embodiments of the present invention provide a bone fixation assembly that can accept and fix fasteners at a plurality of angles. A specific embodiment of a bone fixation assembly **10** is shown as a bone plate **12** and fastener **80** in FIG. **1**. As shown in more detail in FIGS. **2-4**, bone plate **12** has a lower surface **14** and an upper surface **16** and one or more openings **18** that extend from the lower surface **14** to the upper surface **16**.

The embodiments described herein may be used in connection with any type of bone plate, non-limiting examples of which are shown in FIGS. **11-15**. Plate **12** may be adapted to contact one or more of a femur, a distal tibia, a proximal tibia, a proximal humerus, a distal humerus, a clavicle, a fibula, an ulna, a radius, bones of the foot, or bones of the hand. The bone plate may be curved, contoured, straight, or flat. It may be a periarticular plate or a straight plate. An example of a straight plate in shown in FIG. **11**. Plate may have a head portion that is contoured to match a particular bone surface, such as a metaphysis or diaphysis, flares out from the shaft portion, that forms an L-shape, T-shape, Y-shape, with the shaft portion, or that forms any other appropriate shape to fit the bone to be treated. An example of a T-shaped plate is shown in FIGS. **12-15**, the openings on the plates in those figures are described in more detail below.

Bone plate **12** may be comprised of titanium, stainless steel, cobalt chrome, carbon composite, plastic or polymer—such as polyetheretherketone (PEEK), polyethylene, ultra high molecular weight polyethylene (UHMWPE), resorbable polylactic acid (PLA), polyglycolic acid (PGA), combinations or alloys of such materials or any other appropriate material that has sufficient strength to be secured to and hold bone, while also having sufficient biocompatibility to be implanted into a body. Although the above list of materials includes many typical materials out of which bone plates are made, it should be understood that bone plates comprised of any appropriate material are within the scope of this invention.

Opening **18** of plate **12** is shown having a central axis **20**, and it is adapted to receive a fastener. The fastener may be any typical, standard locking fastener or a non-locking fastener, although the embodiments described herein are intended for particular use with locking fasteners that have a series of threads on their heads. FIGS. **5-6** show examples of fastener **80** that may be used in accordance with embodiments of this invention. As shown specifically in FIG. **6**, fastener **80** has a shaft **82** and a head **84**. Shaft **82** may be threaded or otherwise configured to engage bone. It may be fully threaded, partially threaded, comprise a helical blade, and/or may comprise one

or more tacks, deployable talons, expanding elements, or so forth. Any feature that allows shaft **82** to engage bone is considered within the scope of this invention and may be referred to generally as a "threaded shaft" for the sake of convenience. It is also possible, however, that shaft **82** is not threaded, so that fastener **80** takes the form of a peg or a pin. This alternative embodiment may be preferred in certain procedures where, for instance, the main goal is to prevent tilting of a bone segment, or in procedures where there is no concern of fastener **80** pulling out from the bone and hence no need for shaft **82** to be threaded or otherwise configured to engage bone. For the sake of reference, shaft **82** is also shown having a longitudinal axis **86**. The end of shaft **82** may be a self-tapping or self-drilling tip, as shown in more detail in FIG. **5**.

The head **84** of fastener **80** preferably has at least one set of threads **88**. Threads **88** are typically any standard-type thread. For example, the threads **88** may be a continuous ridge or a non-continuous ridge. It may comprise a portion of a revolution, one complete revolution, multiple revolutions, a single lead, or multiple leads, or any other threads known in the art. Additionally or alternatively, head **84** of fastener **80** may include any other surface that will engage with and seat within specific features of plate (described further below). For example, head **84** may have a series of dimples, ridges, bumps, textured areas, or any other surface that can secure fastener **80** as described herein. As will be described in more detail below, threads **88** of head are adapted to engage, associate with, or otherwise cooperate with fins **24** of opening **18**. In short, any type of threaded fastener head is intended for use with various embodiments of this invention.

Referring to FIG. **2**, it can be seen that the embodiment shown has an opening **18** with an inner surface **22** that is defined by a series of concavely indented, inwardly protruding fins **24**. Fins **24** extend into opening **18** toward central axis **20**. The bases **26** of fins **24** form a concave portion **28** at or near a round circumference **30** of upper surface **16**. (The term "round" circumference is intended to refer to any round shape, such as a circle, an oval, an egg-shaped circumference, or any other opening shaped to receive the head of a fastener **80**.) The bases **26** of the fins **24** may all meet in substantially the same plane and then angle downwardly and inwardly at a similar angle or slope.

It bears noting that the concave portion **28** is smooth and non-threaded. In fact, there are not any threads on concave portion **28** or anywhere on inner surface **22** of opening **18**. The lack of threads helps ease the manufacturing of plate **12**, and allows plate be manufactured as thinly as desired.

For example, the thickness of plate **12** and the dimensions of fins **24** are typically dependent upon the pitch and threads of fastener **80**. For example, a larger plate **12** for use with a larger fastener (e.g., for use on a femur bone) will likely be thicker and will have larger and thicker fins than a smaller plate (e.g., for use on a smaller bone). In specific embodiments, the fins **24** are particularly thin so that they can be moved up or down and deformed upon pressure. In some embodiments, the fins may be pressed toward the edges of the plate opening. A non-limiting exemplary range of thicknesses for fins may be from about 0.5 mm to about 5 mm, although larger and smaller sizes are possible. In theory, the fins **24** are intended to fit between crimps on the threadform of fastener **80**, as shown in FIG. **1**.

Providing a non-threaded inner surface **22** also allows the fastener **80** to be inserted into opening **18** at any desired angle, because there are not any threads to interfere with the desired angle, as illustrated by FIG. **5**. The fins **24** are intended to slightly bend, deflect or deform in order to secure the fastener **80** in place in opening **18**. Fins **24** actually engage threads **88** or other surface of fastener **10**.

Referring back to FIG. **2**, in the embodiment shown, as fins **24** extend toward central axis **20**, they taper to form tapered sides **32**. The fins end at rounded tip **34**, although tips **34** can be pointed, square, rectangular, or any other appropriate configuration. For example, as shown in FIGS. **7** and **8**, fins **24** may have straight edges or sides **42** and straight ends **44**. This embodiment shows fins **24** that are partially rectangular-shaped. The openings **46** between fins **24** are slit-shaped.

An alternate embodiment is shown in FIGS. **9** and **10**, which illustrate fins **24** with a more triangular shape. In this embodiment, fins **24** are shown having sides **52** that taper inwardly and edges **54** that are flat and small, forming the apex area **56** where sides **52** come to an end. Openings **58** between fins **24** are more elongated than openings **46**. Both sets of openings **46**, **58** in these alternate embodiments are shown having rounded backs **60**, where they meet inner surface **22** of opening **18**. It should be understood however, that these are merely examples of fin **24** shapes and openings **46**, **58** and that any appropriate shapes are possible and considered within the scope of this invention. Non-limiting examples include trapezoidal, square, round, circular, triangular (with a pointed tip instead of apex area **56**), and any other possible option.

As shown in FIG. **4**, a second circumference **36** at the lower or underneath surface **14** of plate **12** may appear to be more jagged than the round circumference **30** at the upper surface **16** due to the fins **24** forming a portion of lower surface **14**. The circumference can appear almost "flower-like"—each fin **24** appears to form a petal of the circumference. Alternatively, for the embodiments of FIGS. **7-10**, the second circumference will appear similar to the shape created by fins **24**.

Although the figures show an opening **18** with about five to eight fins **24**, it should be understood that any number of fins **24** is considered within the scope of this invention. For example, there may be two or three fins, or ten or twenty or more fins **24**, depending upon the plate for which the opening **18** is intended for use.

The primary purpose of fins **24** is to grasp one or more threads **88** of a threaded head fastener in order to secure the fastener in place in the bone plate **12**, but a desired angle. For example, as opposed to threaded openings (which engage the threads of the head of the fastener in one way only, limiting the surgeon's ability to angle the fastener as desired), the fins **24** of this embodiment are still intended to secure the threads of the head of fastener in place, but at any angle. As the fastener is inserted, its threads start to engage the fins **24**, as shown in FIG. **1**. As discussed above, the fins **24** may be very thin so that as the head threads **88** start to grab fins **24**, the fins **24** may move up or down as appropriate to engage the threads **88** and secure the fastener **80**. In short, the threads **88** engage fins **24** (or fit in between fins **24**). In most cases, this movement of fins **24** is a permanent deformation, so that the fins cannot flex back and allow the fastener to work its way out.

As discussed above, finned openings **18** may be provided on all types of bone plates, examples of which are shown in FIGS. **11-15**. FIG. **11** shows a specific example of an opening **18** with fins **24** (referred to as a finned opening **18**), a smooth opening **60**, a threaded opening **62**, and a provisional pin opening **64**. Other options are holes that can be used with either a threaded or non-threaded fastener, as well as combination slots. It should be understood that these various types of openings may be used on any types of bone plates, in any combination and in any size, examples of which are shown in FIGS. **12-15**. FIG. **12** shows a plurality of finned openings **18** in the head **70** of bone plate **12**. This may help achieve better

fixation of a fractured bone, because the fastener can be inserted at various angles to capture "renegade" or random bone fragments that have split from the bone during fracture, but still secure the bone fragments to the plate. For example, if a wrist bone is broken, there will be numerous fragments that may shatter in various directions. The plates **12** with finned openings **18** described herein can be used to place a fastener **80**—at various angles in order to capture the renegade fragments that would otherwise not be secured to a bone plate using only a locking or a non-locking fastener. It should additionally be understood that other types of openings (in addition to or instead of finned openings **18**) may be present in the head **70**, as well as elsewhere on plate **12**.

As previously mentioned, fastener **80** may be any typical fastener, made out of any appropriate material. It will typically have a bore for receiving a driver in order to secure fastener into bone and into plate **12**. The receiving bore may be any size and shape, for example, it may have a hexagonal configuration to receive a corresponding hexagonal driver, a Phillips screw head, a flat-head, a star configuration, Torx, or any other appropriate configuration that can cooperate with a driver to place fastener.

Turning now to the methods of implantation, the surgeon accesses the surgical site of interest, which can be an internal site at which a bone fracture is located that requires stabilization to ensure proper healing. The fracture may be reduced with conventional forceps and guides (which are known to those in the art), and a bone plate of appropriate size and shape is placed over the fracture site. In some instances, the bone plate may be temporarily secured to the bone using provisional fixation pins. In the bone plates shown in FIGS. **11** and **12**, provisional fixation pins may be used through either the provisional pin openings, or any other opening (threaded or non-threaded or finned) in the plate. Provisional fixation provides for temporarily securing the bone plate to the bone before placing fixation screws through the bone plate, so that one can be certain the bone plate is properly positioned before placing bone screws for permanent fixation of the bone plate to the bone. Moreover, with provisional fixation, x-rays can be taken of the bone plate/construct without excess instruments in the field of view.

Once the plate **12** is secured at a desired location in relation to the fracture (typically using one or more provisional fixation pins, although any other appropriate method may be used), the surgeon then identifies an insertion angle, or the direction along which fastener **80** is to be inserted through a selected opening **18** and driven into bone material. If bone plate **12** includes more than one opening, as shown in the figures, the surgeon also selects the specific opening to be used. After selecting the desired insertion angle and opening, the surgeon inserts shaft fastener **80** through opening **18** until the tip contacts bone material. In some cases, a hole may need to be drilled or tapped into the bone along the insertion angle to facilitate the initial tapping or insertion of fastener **80**. The surgeon then uses an appropriate driving tool in the receiving bore of head **84** to manipulate the fastener **80** into place.

Because fastener **10** may be inserted at angles other than the aligned with the central axis **20** of the opening **18**, as shown in FIG. **5**, fastener **80** may be used to grab or secure bone fragments that are out of line with the traditional angle at which a locking screw would normally be inserted. The surgeon may need to toggle or maneuver the fastener **80** in order to secure and draw in displaced bone fragments.

Once the bone fragment is secured, the fastener **80** is ready to be secured to the plate **12**. As fastener **80** is driven further into bone, it is also drawn further into plate **12**. As threads **88** of fastener head **84** begin to contact fins **24**, the fins are allowed to engage within the threads to hold the fastener **80** in place in the desired angle, even angles that are other than in line with the central axis **20**. The action of engagement between fins **24** and threads **88** rigidly affixes fastener **80** to the bone plate **12** at the desired insertion angle. In some embodiments, the surgeon may then use traditional locking and/or non-locking screws in other openings on plate. This can help further secure the bone plate to the bone fracture if needed. One advantage of opening **18** is that it is adapted to receive any one of the potential fasteners that may be used with plate **12**.

In some instances, once all fasteners and/or screws are placed, the surgeon may place covers over the unused openings, particularly if there are any unused openings that cross the fracture in order to strengthen the plate **12**. Additionally or alternatively, the surgeon may use bone graft material, bone cement, bone void filler, and any other material to help heal the bone.

An alternate embodiment of a fixation assembly is shown in FIGS. **16-18**. These figures show a fastener **102** with a finned head **104**. Specifically, the finned head **104** comprises a receiving bore **106** at its upper portion **108** and at least one set of extending fins **110** around the main portion **112** of the head **104**. Fins **110** are shown as being square or trapezoidally-shaped with tapered edges, although they may be any other shape, such as rounded, oval, rectangular, curved, rhomboid, diamond-shaped, triangular or any other appropriate shape. The edges **111** of fins **110** may taper inwardly, outwardly, or be about parallel with one another. Fins **110** may be provided in a single row around head **104** or layered in multiple rows as shown. If layered in multiple rows, each individual fin **110** may be directly above another fin (so the top of the fastener **100** looks like that shown in FIG. **18**). Alternatively, each individual fin **110** in a lower layer may be offset from a fin in a higher layer. The number of fins **24** in a set may also vary from about two or three up to any desired number that can fit on main portion **112** of head **104**. As with the fins **24** of opening **18** described above, the fins **110** are preferably quite thin, the thickness varying depending upon the use of fastener and plate. For example, a larger fastener **102** for use with a larger plate (e.g., for use on a femur bone) will likely have larger and thicker fins **110** than a smaller fastener (e.g., for use on a smaller bone). In specific embodiments, the fins **110** are particularly thin so that they can be moved up or down or compressed upon pressure. A non-limiting exemplary range of thicknesses for fins may be from about 0.5 mm to about 5 mm, although larger and smaller sizes are possible. In theory, the fins **110** are intended to fit between the threadform of plate. Fastener may also have a shaft **114** that is threaded or unthreaded, as described above with respect to fastener **80**.

Fastener **102** may be used with any bone plate that has a threaded opening. Any of the examples shown in the figures described above may be used with fastener **102**. One option of a specific bone plate that can be used with fastener **110** is shown in FIG. **19**. This bone plate **120** has Acme threads **124** that have a more rectangular shape than the pointed, sharp threads that are typically used in bone plates. As shown in FIG. **20**, opening **122** has threads **124** that end at their edges **126** in a rectangular shape. Providing a rectangular shape with a flatter edge **126** allows a larger channel for the fins **110** to engage. In an even more specific embodiment, the threads **124** may be angled at about 15-20° off of the central axis **130** of opening **122**, and even more specifically, at about 18° off of the central axis **130**.

An example of the method of use is similar to that describe above. As fastener **102** is being inserted into bone plate **120**

(although it should be understood that any traditional bone plate may used; Acme threads are not a requirement), the fins **110** are intended to engage threads of the plate and, much like the fins of the bone plate described above, fins **110** are very thin so that as the threads of plate **120** start to grab the fins **110**, the fins **110** may move up or down as appropriate to engage the threads of plate and secure the fastener **102** in place, as shown in FIG. **16**. In most cases, this movement of fins **110** is a permanent deformation, so that the fins cannot flex back and allow the fastener to work its way out.

II. Low Profile Plates

Generally

FIGS. **23-89** show a number of low profile plates in accordance with certain embodiments of the invention. In general, such low profile plates can be used to treat partial articular fractures of the distal and proximal tibia such as those shown in FIGS. **22***a* and **22***b* and classified as AO/OTA Fracture classification type B. Such plates can also be used to treat such fractures in other bones, including, for example, portions of the metatarsals, calcaneous, other ankle and foot bones, humerus, radius, ulna, spinal, maxillofacial, and other bones. A tubular plate as shown in FIGS. **79-84** can be used to treat fractures, nonunions and osteotomies of the medial malleolus, fibula, distal ulna, olecranon, calcaneus, and metatarsals, among other bones.

Certain embodiments of such low profile plates are particularly useful in connection with periarticular fractures and fractures that do not bear full body weight. They are generally contraindicated for treatment of AO/OTA fracture classification types A and C, as well as fractures with extreme metaphyseal, comminution or dissociation of the articular segment from the bone shaft. Such low profile plates, subject to these limitations, can also be used in connection with osteopenic bone.

Generally, certain embodiments of such low profile plates can feature thicknesses of approximately 2 mm or less. Other thicknesses are possible. This thin or low profile acts together with the contouring of the plates, any desired edge treatment and screw-head shape to minimize wear of or effect on soft tissue surrounding the installed plates. The thin profile also acts in combination with the dimensions of the plate to provide a structure that is generally more flexible than conventional bone plates and thus particularly suitable for low profile, bone contouring, non-full body weight or physiological load bearing fixation in metaphyseal areas of bones such as, for example without limitation, tibia and fibula.

These structural and material characteristics of some embodiments of such low profile plates can also provide plates which can be applied to achieve a buttress effect, whereby mid portions of the plate are compressed against bone using one or more cortex, compression or osteopenic screws and thereafter fixation is accomplished with polyaxial locking screws using polyaxial openings that can accept locking screws polyaxially. FIG. **21**B schematically illustrates aspects of this buttressing effect. It shows a plate **175** that is not precisely shaped according to bone contour; rather, in one or more areas such as near the midportion of the plate **175**, there is a gap between the plate **175** and the bone. When a compression screw **177** is inserted and torqued into the bone, the screw **177** pulls the plate **175** toward the bone or compresses the plate **175** on the bone. Flexibility or "springiness" of the plate **175**, particularly in low profile plates according to certain embodiments of the invention, causes portions of the plate **175** located more toward the ends to bear against the bone or bone fragments in such a way that stabilization of the fracture is enhanced. The buttressing effect is assisted by insertion of locking screws into polyaxial openings of the plate to help create a more integral bone/plate construct for better stabilization, particularly in periarticular fractures. Certain low profile plates according to certain embodiments of the invention can be applied to bone in a reinforcement mode, rather than the buttress mode.

Low profile plates according to certain embodiments of the invention are particularly well suited to challenges presented by partial articular fractures. Factors such as intra-articular fracture extension, fracture pattern instability, and inadequate soft tissue coverage are addressed by plates according to certain embodiments of the invention that are preferably both versatile and comprehensive in their approach to fracture fixation. Traditional locked plating systems can enhance fracture stability through predetermined screw trajectories and precise plate position on bone. The enhanced stability can, however, reduce intraoperative versatility with respect to plate and screw placement. However, polyaxial locked low profile plates according to certain embodiments of the invention offer a greater degree of freedom relative to final implant position in connection with partial articular fractures and other fractures. According to certain embodiments, locking screws that feature heads with threads on their periphery, such as for example, conventional locking screws, can be inserted and retained in polyaxial openings in the plate up to 15 degrees in any direction and require no additional implants or procedural steps to ensure definitive locking. Low profile fixation in areas where implant prominence is a chief concern is accomplished by minimizing plate thickness near the joint without compromising needed implant strength, and minimizing screw head protrusion beyond the plate exterior surface in a way that would irritate surrounding tissue.

Accordingly, low profile plates according to certain embodiments of the invention take advantage of three features:

(1) Polyaxial locking;

(2) Low profile; and

(3) Enhanced plate contouring.

According to certain embodiments, tabbed openings include a number of separate tabs, preferably but not necessarily five, that engage with threads of the locking screw head to form a fixed angle construct. Structure of tabs depends on a number of factors including thickness of plate, desired use of the plate, materials, types of screws contemplated for the plate, and other factors. Locking screws can be angled and locked up to 15 degrees in any direction, allowing for the creation of customized, multi-directional locked plating constructs. Preferably, each opening can accept 3.5 mm cortex, 3.5 mm locking and/or 5.0 mm osteopenia screws. Other types of screws may be used in connection with such openings, including other compression, cortex, locking, and/or osteopenia screws. Other types of polyaxial openings can also be used, as disclosed for example in Section I above. Preferably, openings are formed such that a locking screw can be withdrawn and reinserted a multiple number of times, including in different directions, without losing substantial angular retention of the screw by the plate.

The low profile feature ensures low profile fracture fixation in areas of minimal soft tissue coverage such as periarticular zones. Preferably, all screws also have a low head profile further to reduce potential for soft tissue irritation in these sensitive areas. Preferably, the thickness of such plates is approximately 2 mm or less.

Enhanced plate contouring not only minimizes prominence of the plate and therefore reduces potential for soft tissue irritation, but also facilitates fracture reduction and stabilization by allowing, if desired, mid portions of the plates to be compressed to bone to achieve buttressing effect. This

effect helps, among other things, to resist torque and bending during fracture healing. Once securely fixed in place using such compression techniques, the plate produces a buttress effect to the fracture site to help prevent loss of reduction and enhance overall fracture fixation. Achieving buttressing effect is not necessary, however; the plates can also be installed in a reinforcement mode. Contouring also allows additional screw convergence in metaphyseal areas of bone.

Low profile plates according to certain embodiments of the invention are preferably made from ASTM F 139 Implantable Stainless Steel material or equivalent. Other suitable materials include titanium, titanium alloy, or any other bio compatible material which allows plates to perform satisfactorily with polyaxial locking, low profile and enhanced plate contouring features of embodiments of the invention. Indentations or undercuts, shown for example with numeral **521** in FIG. **51**, can be formed in the interior surfaces of any such plates, including those for the tibia or fibula disclosed below, where desired to increase flexibility at certain locations; such indentations can be oriented perpendicular to the length of the plates or as other wise desired.

Various types of openings can be used in low profile plates according to certain embodiments of the invention, including embodiments of plates disclosed below. Such openings can include, for example, tabbed openings as disclosed below, other polyaxial openings that are intended to receive and retain a locking screw at multiple angles, conventional threaded openings, conventional nonthreaded openings, slots, openings as disclosed in U.S. Pat. No. Re. 31628 reissued Jul. 10, 1984 to Allgower, et al., and/or openings as disclosed in U.S. Pat. No. 6,322,562 issued Nov. 27, 2001 to Wolter. U.S. Pat. No. Re. 31628 and U.S. Pat. No. 6,322,562 are herein incorporated by reference.

Following is a discussion of examples of certain low profile plates that incorporate these principles and that can be used in areas of the lower leg. Low profile plates according to embodiments of the invention can be used in other bones, as discussed above, but the following are nonlimiting examples.

Lateral Distal Fibula Plates

FIG. **23** is a posterior view of distal portions of a tibia and fibula with a lateral distal fibula locking plate according to one embodiment of the invention installed on the fibula. Generally, plate **200** also contains a head **214**, a generally elongated shaft **216** and a transition portion **218** which generally connects the head **214** and shaft **216**. Plate **200** includes an exterior surface **202**, a bone contacting or partially bone contacting interior surface **204**, a left edge **206**, a right edge **208**, a head end **210** and a shaft end **212**. Exterior surface **202** may be generally convex, flat, or shaped as otherwise desired. Interior surface **204** may be generally concave, flat, or shaped as otherwise desired. Interior surface **204** can contain one or more indentations or undercuts which traverse across the interior surface **204** to modify flexibility of the plate, reduce bone contact, or other purposes.

Plate **200** is shaped to lie along the lateral aspect of the distal fibula and includes a cluster of tabbed openings **220** in the head through which screws can penetrate portions of the lateral malleolus. The transition portion **218** angles laterally, or toward the exterior surface **202**, proceeding from shaft **216** to head **214**. The head **214** is preferably cupped to conform to portions of the lateral malleolus. The shaft **216** is preferably shaped according to a traditional ⅓ tubular plate conventionally used to treat fibula fractures. Edges can be rounded and the shaft end **212** is preferably chamfered to facilitate percutaneous insertion.

FIGS. **25***b* and **25***c* show detail relating to tabbed openings **220** that can be formed in plate **200**. The plan view of FIG. **25***b* shows a tabbed opening **220** containing five tabs **222** and valleys **224**. More or fewer tabs **222** can be used. Tabs **222** can but need not have an extremity **226** which can be but need not be of constant radius. Similarly, valleys **224** can if desired feature a constant radius. In cross section, as shown in FIG. **25***c*, the tabs **222** feature a concave or dished outer surface **228** and an inner surface **230** that can conform to the shape of the interior surface **204** of plate **200**. Tab outer surfaces **228**, as can be appreciated with reference to FIGS. **25***b* and **25***c*, together with portions of the opening **220** radially outward of valleys **224**, form a dished compression screw receiving surface **232** that can be dished or otherwise formed to receive the head of a compression, cortex or osteopenic screws, or other suitable screw that can act to impart compression on a bone plate as it is rotated into the bone. Preferably as shown in FIG. **25***c*, but not necessarily, receiving surface **232** features a constant cross sectional radius. The particular structure shown in FIG. **25***c* allows opening **220** to receive and retain or lock relative to the plate in angularity 3.5 mm locking screws at orientations or angles up to 15 degrees in any direction from axial. That structure also allows openings **220** to receive 3.5 mm cortex and/or 5.0 mm osteopenia screws for compressing mid portions of plates according to embodiments of the invention against bone for buttress effect.

Preferably, the axis **234** of opening **220** is normal to a tangent formed at the center of the opening to the interior surface **204** of plate **200**. Axis **234** could also be oriented normal to a tangent at the center of opening **220** to exterior surface **202** of the plate. Axis **234** could also be normal to or angulated with respect to either exterior surface **202** or interior surface **204** or any other desired structure on plate **200**.

Preferably, tab inner surfaces **230** are flush with the interior bone contacting surface **204** of plate **200**. Tab inner surfaces **230** do not need to be flush in that manner, however; they could be planar and/or recessed from interior bone contacting surface **204** if desired.

In operation, tab extremities **226** engage or cooperate with threads in locking screws, such as for example by interdigitating with the threads, or inserting themselves between the threads and deflecting, to allow a locking screw to be inserted at a desired angle, and the tabs **222** then to retain the screw at that angle or in that orientation or substantially that orientation relative to the plate **200**.

Other types of polyaxial openings **220**, such those disclosed for example in Section I above, can also be used for plate **200** in accordance with embodiments of the invention. Additionally, plate **200** can contain other types of threaded or nonthreaded openings and/or slots as discussed above in this document.

FIG. **24***b* shows a lateral distal fibula plate **200** with a cortex or compression screw **236** inserted to compress mid portions of plate **200** against the fibula to achieve buttressing effect. Two locking screws **238** fix the plate **200** to the fibula proximal to the cortex screw **236** and three locking screws **238** fix portions of plate **200** distal to cortex screw **236** to portions of the lateral malleolus or distal portions of the fibula. FIGS. **25***a* and **26-30** show various views of plate **200**.

The particular plate **200** shown in FIG. **23** features a thickness of 0.067 inches plus or minus 0.005 inches (1.7 mm plus or minus 0.127 mm), but other thicknesses could be used, preferably approximately 2 mm or less. Plate **200** is preferably machined from ASTM F 139 Implantable Stainless Steel material, but other materials as discussed above could be used. Plate **200** is preferably machined from the material, but could be punched, forged, cast, made according to any combination, or as otherwise desired.

Posterolateral Distal Fibula Plates

FIGS. **31-38** show a posterolateral distal fibula plate according to one embodiment of the invention. Plate **300** includes an exterior surface **302**, a bone contacting or partially bone contacting interior surface **304**, a left edge **306**, a right edge **308**, a head end **310** and a shaft end **312**. Exterior surface **302** may be generally convex, flat, or shaped as otherwise desired. Interior surface **304** may be generally concave, flat, or shaped as otherwise desired. Interior surface **304** can contain one or more indentations or undercuts which traverse across the interior surface **304** to modify flexibility of the plate, reduce bone contact, or other purposes.

Preferably more toward the head end **310** than the shaft end **312**, a number of scallops **314** can be formed in the lateral facing edge of plate **300** as installed. A rounded corner **311** can be formed at the right edge **308**/head end **310** intersection, and elsewhere as desired. Scallops **314** provide space in which a syndesmotic screw **316** can be inserted without undue interference by plate **300**. Scallops **314** can be any desired shape. Plate **300** is otherwise generally in the shape of a ⅓ tubular conventional fibular plate, with a twist added to the head-end portion **310**. The twist is preferably but not necessarily 8 degrees in an axial direction (counterclockwise proceeding toward head end **310** in the plate **300** shown in the drawings). The twist is provided to help avoid the peroneal nerve when the plate **300** is applied to the fibula.

FIG. **31** shows a compression screw **336** inserted in the third opening **320** from distal. Two locking screws **338** are inserted on the distal side of the fracture and syndesmotic screw **316**. A compression screw **336** is inserted at the proximal end of the plate **300** and two locking screws **338** are inserted in the next two openings **320**.

Plate **300** preferably features polyaxial openings **320** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **300** can contain other types of threaded or nonthreaded openings and/or slots as discussed above in this document.

FIG. **32***b* is a radiograph showing plate **300** applied to bone.

FIGS. **33-38** show various views of the plate **300**.

Lateral Proximal Tibia Plates

FIG. **39** is a posterior view of portions of a tibia and fibula with an installed lateral proximal tibia plate according to one embodiment of the invention. Plate **400** includes an exterior surface **402**, a bone contacting or partially bone contacting interior surface **404**, a left edge **406**, a right edge **408**, a head end **410**, and a shaft end **412**. Exterior surface **402** may be generally convex, flat, or shaped as otherwise desired. Interior surface **404** may be generally concave, flat, or shaped as otherwise desired. Interior surface **404** can contain one or more indentations or undercuts which traverse across the interior surface **404** to modify flexibility of the plate, reduce bone contact, or other purposes. The plate **400** is generally "L" shaped, the foot of the "L" forming the head **414** that is ultimately installed adjacent the lateral condyle of the tibia. A transition **418** transitions to a shaft **416** that preferably features a chamfered end.

The plate **400** lies along the lateral aspect of the proximal tibia. A five degree posterior tilt in the transition section **418** aligns opening **420** with the contour of the lateral tibial condyle. Plate coverage extending down the shaft **416** is enhanced by imparting a three degree sagittal twist (counterclockwise, proceeding toward head **414** in the plate **400** shown in the drawings) in the plate's proximal segment, which can include transition portion **418**. Head portion **414** forms a concavity that conforms to the convexity of the lateral condyle. The head end **414** preferably features one or more scallops **422** to accommodate lag or rafter screws that can be used to reinforce the articular surfaces of the tibia. Scallops **422**, if used, can be formed of any desired shape generally to help alleviate interference between plate **400** and the lag screws. The plate preferably does not conform precisely flush to the diaphyseal/metaphyseal transition of the tibia; the non correspondence allows compression or mid portions of plate **400** against bone for buttressing effect.

FIG. **39** shows a compression screw **436** across the fracture, with the head **414** receiving three locking screws **438** and the shaft **416** receiving three locking screws **438** on the other side of the fracture from the head **414**.

Provisional openings **424** can be included in head **414** to accept K-wires or other structure for temporary placement of the plate **400** on bone, for provisional fixation of bone elements, and/or for visualization of screw trajectory as desired. Such openings **424** are also potentially useful in connection with guide **440** shown in

FIG. **40** that allows visualization of plate position and provides a template for independent lag screw placement relative to scallops **422** of plate **400**. K-wires can be inserted through the two proximal holes **442** to aid in provisional fixation and fracture reduction, together with such visualization. The guide **440** can be removed over the K-wires and the plate **400** applied over the K-wires if desired.

Plate **400** preferably features polyaxial openings **420** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **400** can contain other types of threaded or nonthreaded openings and/or slots as disclosed in this document.

FIG. **41***b* is a radiograph of an installed lateral proximal tibia plate **400**. FIGS. **42-47** show various views of plate **400**.

Posteromedial Proximal Tibia Plates

FIG. **48** is a medial view of portions of a tibia with a posteromedial proximal tibia plate according to an embodiment of the invention installed. Plate **500** includes an exterior surface **502**, a bone contacting or partially bone contacting interior surface **504**, a left edge **506**, a right edge **508**, a head end **510** and a shaft end **512**. Exterior surface **502** may be generally convex, flat, or shaped as otherwise desired. Interior surface **504** may be generally concave, flat, or shaped as otherwise desired. Interior surface **504** can contain one or more indentations or undercuts (shown as numeral **521**) which traverse across the interior surface **504** to modify flexibility of the plate, reduce bone contact, or other purposes. Head **514** generally forms the top of a "T" with respect to shaft **516**. A transition portion **518** imparts a posterior angle in plan view, or medial angle in side view, proceeding from shaft **516** to head **514**. Additionally, an axial twist (counterclockwise proceeding to head **514** in the plate **500** shown in the drawings) allows the head **514** to conform more closely to the medial condyle. The head **514** forms a concavity that generally conforms to the convexity of the medial condyle.

Head end **510** preferably includes scallops **522** for purposes of accommodating lag screws as disclosed in connection with plates **400**. Plate **500** can also contain provisional openings **524** as disclosed in connection with plates **400** to accommodate K-wire or other provisional fixators for purposes of visualization of screw trajectory, provisional fixation and as otherwise desired. Shaft end **512** preferably features a chamfered portion for percutaneous insertion.

FIG. **49***b* is a radiograph that shows a compression screw **536** inserted through an opening **520** across the fracture.

Three locking screws **538** are inserted through the head and four locking screws **538** are inserted along the shaft. FIGS. **50-55** show various views of plate **500**.

Plate **500** preferably features polyaxial openings **520** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **500** can include other threaded or nonthreaded openings and/or slots as disclosed in this document.

Medial Distal Tibia Plates

FIG. **56** is an anterior view of distal portions of a tibia and fibula with a medial distal tibia plate **600** according to an embodiment of the invention installed. Plate **600** includes an exterior surface **602**, a bone contacting or partially bone contacting interior surface **604**, a left edge **606**, a right edge **608**, a head end **610** and a shaft end **612**. Exterior surface **602** may be generally convex, flat, or shaped as otherwise desired. Interior surface **604** may be generally concave, flat, or shaped as otherwise desired. Interior surface **604** can contain one or more indentations or undercuts which traverse across the interior surface **604** to modify flexibility of the plate, reduce bone contact, or other purposes. The shaft **616** transitions to a transition portion **618** which flares to form a head **614** that is flared and generally cupped to accommodate portions of the medial malleolus or distal tibia. The concavity on the interior surface **604** of head **614** allows openings **620** to be oriented so that screws **638** can converge in metaphyseal portions of the tibia. The distal-most openings **620** are preferably positioned just superior to the plafond. The plate **600** features a sagittal twist in at least the transition portion **618** (clockwise proceeding toward head **614**). The openings **620** in head **614** are preferably staggered to allow for a greater concentration of locking screws **638** into the metaphyseal portion of the tibia, and also for those screws to converge for additional fixation benefits. FIG. **56** shows a compression screw **636** placed across the fracture with locking screws **638** inserted proximal to the fracture and other locking screws **638** through the head **614**.

Provisional openings **624** as discussed in connection with plate **400** can be used. Plate **600** preferably features polyaxial openings **620** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **600** can contain other types of threaded or nonthreaded holes and/or slots as disclosed in this document.

FIGS. **57-62** show various views of plate **600** that make more apparent, among other things, the cupped shape of the head **614** and the sagittal twist.

Anterior Distal Tibia Plates

FIG. **63** shows an anterior view of distal portions of a tibia with an anterior distal tibia plate **700** according to one embodiment of the invention installed. Plate **700** includes an exterior surface **702**, a bone contacting or partially bone contacting interior surface **704**, a left edge **706**, a right edge **708**, a head end **710** and a shaft end **712**. Exterior surface **702** may be generally convex, flat, or shaped as otherwise desired. Interior surface **704** may be generally concave, flat, or shaped as otherwise desired. Interior surface **704** can contain one or more indentations or undercuts which traverse across the interior surface **704** to modify flexibility of the plate, reduce bone contact, or other purposes. The shaft **716** transitions to a transition portion **718** that angulates anteriorally as does, preferably, head **714**, with respect to shaft **716**. The transition **718** and head **714** form a delta shape to accommodate fixation into the metaphyseal portion of distal tibia. Material may be removed or omitted to form windows **740** which can be shaped as desired. Windows **740** can help with respect to bone loss and also provide additional opportunities for fixation. Head **714** features a generally concave inner surface **704** to accommodate the general convex shape of the anterior distal tibia. Head end **710** can include one or more scallops **722** that can be formed to allow plate **400** to accommodate or minimally interfere with placement of lag screws or other fixation screws. Provisional openings **724** can be provided as discussed in connection with plate **400**. Preferably, the shaft end **712** features a chamfer for percutaneous insertion.

Plate **700** preferably features polyaxial openings **720** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **700** can contain other types of threaded or nonthreaded openings and/or slots as disclosed in this document.

FIG. **64** shows an anterior distal tibia positioning guide **742** for use during installation of plate **700**. Guide **742** can feature provisional openings **744** and scallops **746** such as the kinds disclosed in connection with guide **440** disclosed above. Guide **744** can allow visualization of plate **700** position and provide a template for independent lag screw placement in the distal tibia relative to scallops **722** in plate **700**. K-wires can be inserted through the two distal provisional holes **744** to aid with provisional fixation and fracture reduction. The guide **742** can be removed over the K-wires and the selected plate **700** then applied over them.

FIG. **65***b* is a radiograph that shows a plate **700** installed on a tibia. FIGS. **66-71** show various views of plate **700**.

Posterior Distal Tibia Plates

FIG. **72** is a medial view of a distal portion of a tibia with a posterior distal tibia plate **800** according to one embodiment of the invention installed. Plate **800** includes an exterior surface **802**, a bone contacting or partially bone contacting interior surface **804**, a left edge **806**, a right edge **808**, a head end **810** and a shaft end **812**. Exterior surface **802** may be generally convex, flat, or shaped as otherwise desired. Interior surface **804** may be generally concave, flat, or shaped as otherwise desired. Interior surface **804** can contain one or more indentations or undercuts which traverse across the interior surface **804** to modify flexibility of the plate, reduce bone contact, or other purposes. Plate **800** is shaped generally to fit the posterior aspect of the distal tibia with head end **810** resting just superior to the tibial plafond. The shaft **816** transitions in transition area **818** to an enlarged head **814**, so that the transition **818** and the head **814** accommodate three openings **820**. The shaft **816** and transition **818** feature a coronal axial twist (counterclockwise proceeding toward the head in the plate shown in the drawings) to allow conformance to the bone. The transition portion **818** and head **814** also angle posteriorly relative to the shaft **816**, as shown in FIG. **72**. Plate **800** can include one or more scallops **822**, which may be formed as disclosed in connection with plate **400**, to accommodate and minimize interference with lag screws in the metaphyseal area of the tibia. Provisional openings **824** can be used as disclosed in connection with plate **400**.

Plate **800** preferably features polyaxial openings **820** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the technique disclosed in connection with plate **200**. Additionally, plate **800**

can contain other types of threaded or nonthreaded openings and/or slots as disclosed in this document.

FIGS. **73-78** show various views of plate **800**.

Linear Plates

FIGS. **79-84** show a low profile linear plate **900** in accordance with an embodiment of the invention. Plate **900** includes an exterior surface **902**, a bone contacting or partially bone contacting interior surface **904**, a left edge **906**, a right edge **908**, a first end **910**, and another end **912**. Exterior surface **902** may be generally convex, flat, or shaped as otherwise desired. Interior surface **904** may be generally concave, flat, or shaped as otherwise desired. Interior surface **904** can contain one or more indentations or undercuts which traverse across the interior surface **904** to modify flexibility of the plate, reduce bone contact, or other purposes. The plate contains multiple tabbed openings **920** each of which can accept a compression or osteopenic screw **936** or a locking screw **938**. Plate **900** also includes a mid portion **940** without a tabbed opening **920**, to accommodate greater bending moments located in this area of plate **900**. Such a plate **900** can be seen installed on bone in the radiograph shown in FIG. **65***b*. The linear plate can include scallops along either or both edges as described above, as well as provisional holes and indentations on the interior surface, and/or other features as desired.

Plate **900** preferably features polyaxial openings **920** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the techniques disclosed in connection with plate **200**. Additionally, plate **900** can contain other types of threaded or nonthreaded holes and/or slots as disclosed in this document.

Low Profile Plates with Slotted Head

FIGS. **85***a* and **85***b* show a low profile plate **1000** with one or more slots **1021** in addition to polyaxial openings **1020** in accordance with an embodiment of this invention. Plate **1000** can be any of the low profile plates disclosed above or any other low profile plate as desired, for any bone, which features the polyaxial openings, low profile and enhanced coutouring features according to embodiments of the invention. FIGS. **85***a* and **85***b* show, for purposes of illustration, a modified lateral proximal tibial plate **1000** similar to plate **400**, but with a slot or elongated opening in head **1014**. Plate **1000** includes an exterior surface **1002**, a bone contacting or partially bone contacting interior surface **1004**, a left edge **1006**, a right edge **1008**, a head end **1010**, and a shaft end **1012**. Exterior surface **1002** may be generally convex, flat, or shaped as otherwise desired. Interior surface **1004** may be generally concave, flat, or shaped as otherwise desired. Interior surface **1004** can contain one or more indentations or undercuts which traverse across the interior surface **1004** to modify flexibility of the plate, reduce bone contact, or other purposes. The head **1014** contains, in this particular embodiment, an elongated opening or slot **1021** which can be partially tabbed or otherwise fitted with polyaxial screw retention structure as shown in FIG. **85***b* or without tabs or such structure as shown in FIGS. **85***a*. The slot **1021** allows additional flexibility in placement of fixation screws, whether locking in ends of the slot **1021** shown in FIG. **85***b*, or compression screws which can be inserted in slots **1021** of either plates **1000** shown in FIG. **85***a* or **85***b*. Accordingly, a slot **1021** as shown in FIG. **85***b*, regardless of which plate it may be used on, can accept either cortex, compression, osteopenic screws **1036** or locking screws **1038**. Such a slot **1021** can also be formed in the shaft if desired, as shown in FIGS. **85***a* and *b*. Scallops **1022** and/or provisional openings **1024** can be included as disclosed above in connection with plate **400**.

Plate **1000** preferably features polyaxial openings **1020** as disclosed in connection with openings **220** of plate **200**, and a thickness as disclosed in connection with plate **200**. It is preferably formed of the material and by the technique disclosed in connection with plate **200**.

Spinal Low Profile Plates

FIG. **86** shows a low profile spine plate **1100** in accordance with one embodiment of the invention. Plate **1100** can be shaped like a conventional spine plate and can include an exterior surface **1102**, an interior surface **1104**, a left edge **1106**, a right edge **1108**, a first end **1110**, and another end **1112**. The plate can contain polyaxial openings **1120** which can be formed as disclosed in connection with openings **220** of plates **200**. Plate **1100** can have a thickness as disclosed in connection with plate **200**, or thinner if desired. Plate **1100** can be formed using materials and techniques as disclosed in connection with plate **200**.

Uniaxial/Polyaxial Low Profile Plates

FIG. **87** shows a low profile plate **1200** according to another embodiment of the invention. Plate **1200** is generally like that shown in FIG. **12**, except that it can be formed with a thickness as disclosed in connection with plate **200**, it can contain polyaxial openings **1220** as disclosed in connection with plate **200**, and it has enhanced bone contouring in accordance with embodiments of the invention. Plate **1200** includes an exterior surface **1202**, an interior surface **1204**, a left edge **1206**, a right edge **1208**, a first end **1210** and a second end **1212**. Exterior surface **1202** may be generally convex, flat, or shaped as otherwise desired. Interior surface **1204** may be generally concave, flat, or shaped as otherwise desired. Interior surface **1204** can contain one or more indentations or undercuts which traverse across the interior surface **1204** to modify flexibility of the plate, reduce bone contact, or other purposes. Plate **1200** may be any of the plates disclosed above or any other desired low profile plate for any bone which features at least one polyaxial opening **1220** as disclosed above in connection with plate **200**, and the low profile and enhanced contouring features of embodiments of the invention. Openings **1220** can be formed in the head, shaft, or any other desired portion of a plate. The plate **1200** can also, if desired, contain one or more conventionally threaded openings **1222** at any desired location, such as where locking functionality is needed but polyaxial locking functionality is not needed. Plate **1200** can also contain one or more slots or elongated openings **1224** at any desired location. The slots can be either partially conventionally threaded or tabbed as disclosed in connection with the slots **1021** of FIGS. **85***a* and **85***b*. One or more provisional openings **1126** can also be included if desired. Conventionally threaded openings **1222** can accept compression screws, locking screws, or locking pegs as shown in FIG. **12**. Plate **1200** can be formed using materials and techniques as disclosed in connection with plate **200**.

Low Profile Plates with Slotted Shaft

FIGS. **88***a* and **88***b* show low profile plates according to an embodiment of the invention that include at least one slot **1321** in the shaft. Plate **1300**, shown in FIG. **88***a*, which can take the shape of any of the low profile plates disclosed in this document, or other low profile shape as desired, for any desired bone surface, includes an exterior surface **1302**, an interior surface **1304**, a left edge **1306**, a right edge **1308**, a first end **1310**, and a second end **1312**. Exterior surface **1302** may be generally convex, flat, or shaped as otherwise desired. Interior surface **1304** may be generally concave, flat, or shaped as otherwise desired. Interior surface **1304** can contain one or more indentations or undercuts which traverse across the interior surface **1304** to modify flexibility of the

plate, reduce bone contact, or other purposes. Polyaxial openings **1320** can be formed as disclosed in connection with openings **220** of plate **200**. A slot **1321** is included mid plate such as in shaft **1328**. The slot **1321** allows additional flexibility in fixation, and can be configured as disclosed in connection with slots **1021** of plate **1000**, to accept cortex, compression, osteopenic, locking or other screws.

Plate **1400**, shown in FIG. **88***b*, which can take the shape of any of the low profile plates disclosed in this document, or other low profile shape as desired, for any desired bone surface, includes an exterior surface **1402**, an interior surface **1404**, a left edge **1406**, a right edge **1408**, a first end **1410**, and a second end **1412**. Exterior surface **1402** may be generally convex, flat, or shaped as otherwise desired. Interior surface **1404** may be generally concave, flat, or shaped as otherwise desired. Interior surface **1404** can contain one or more indentations or undercuts which traverse across the interior surface **1404** to modify flexibility of the plate, reduce bone contact, or other purposes. Polyaxial openings **1420** can be formed as disclosed in connection with openings **220** of plate **200**. A slot **1424** is included mid plate such as in shaft **1428**. The slot **1324** allows additional flexibility in fixation, and can be configured as disclosed in connection with slots **1021** of plate **1000**, to accept cortex, compression, osteopenic, locking or other screws. FIG. **88***b* shows that a slot **1424** can also be included in a head portion **1430** of the plate **1400**. Provisional openings, scallops, and other features can also be included in plates such as plates **1300**, **1400**, if desired. Plates **1300**, **1400** can be formed using materials and techniques disclosed in connection with plate **200**.

Partial Low Profile Polyaxial Plates

FIGS. **89***a* and **89***b* show partial low profile/partial load-bearing plates **1500** according to an embodiment of the invention. Plate **1500** can be shaped as is conventional for a load-bearing plate for any desired bone, or as otherwise desired. Plate **1500** includes an exterior surface **1502**, an interior surface **1504**, a left edge **1506**, a right edge **1508**, a head end **1510**, and a shaft end **1512**. Exterior surface **1502** may be generally convex, flat, or shaped as otherwise desired. Interior surface **1504** may be generally concave, flat, or shaped as otherwise desired. Interior surface **1504** can contain one or more indentations or undercuts which traverse across the interior surface **1504** to modify flexibility of the plate, reduce bone contact, or other purposes. Plate **1500** can contain a low profile section **1530** as disclosed in this document, with thickness as disclosed in connection with plate **200**, and polyaxial openings **1520** formed as disclosed for openings **220** in plates **200**. Any portion of the plate **1500**, including low profile section **1530**, load-bearing section **1532** or both, can include one or more provisional openings **1526**. Load-bearing portion **1532** can include, as desired, any combination of conventionally threaded openings **1522**, non-threaded openings **1523**, and conventionally non-threaded, partially threaded or partially-polyaxially locking structured slots **1524**. Slots **1524** can be included in the shaft portion **1534** and/or, if desired, in head **1536**. The particular plate **1500** shown in FIG. **89***a* includes in its head **1536** a low profile section adapted to accommodate a metaphyseal portion of a bone. A portion of the head **1536** of plate **1500** of FIG. **89***a* is shown in cross section in FIG. **89***c*. Plate **1500** shown in FIG. **89***b* is similar in concept to that shown in FIG. **89***a* except that the entire head **1536** is formed as a low profile plate in accordance with embodiments of the invention, while the shaft **1534** is formed as a load-bearing section. In these plates **1500**, the load-bearing sections **1532** and the low profile sections **1530** can be demarcated as desired to carry out fixation that allows at least part of the plate to bear physiologic loads such as body weight and another part of the plate **1500** to operate in accordance with the low profile principles disclosed in this document.

Installation of Low Profile Plates

Low profile plates according to certain embodiments of the invention can be installed as follows. They can be used in connection with intramedullary nails, external fixators and/or other devices, wherein the nail or other structure absorbs body load, and the plate is used primarily to buttress fragments, stabilize the fracture and otherwise assist in treatment.

A C-arm can be used for fluoroscopy, including preferably arranged to show the AP plane from lateral positioning. X-rays can be taken ahead of time and an acetate or other template can be provided that allows selection of plate and screw sizes. An incision is made and the plate can be inserted percutaneously or as otherwise desired. Fluoroscopy may be used to ensure that the plate is correctly located. Portions of the metaphyseal area can be opened as desired for reduction of the fracture, access, and other purposes. Wires, forceps and other conventional instruments, components, and techniques can be used to restore and reduce the joint. Provisional fixation holes can be used for K-wires to assist in this process, to provisionally fix the plate to bone, to fix bone fragments and perform reduction, and/or to visualize screw trajectory as desired.

A non-locking screw, such as a cortex, compression or osteopenic screw, can be inserted in one of the openings in the mid portion of the plate to compress that portion against bone to enhance or achieve buttressing effect. The plate can be installed without such compression to perform reinforcement if desired. Drill guides such as those disclosed in PCT/US2007/085210 filed Nov. 20, 2007, which claims priority to U.S. Ser. No. 60/866,665 filed Nov. 21, 2006, both owned by the owner of this document, can be employed as desired. Preferably, two or three holes are filled with locking screws below the fracture and two or three above, although more or fewer holes can be used. The length or orientation of screws can be changed multiple times, such as up to three, with tabbed openings such as those disclosed above in connection with FIGS. **25***b* and *c*. Torque can be applied using conventional torque limiters, which are preferably set not to exceed 1.7 Newton-meters or 16 inch pounds. Alternatively, locking screws can be hand torqued for final torquing. Wound closure follows conventional technique.

The foregoing description of exemplary embodiments of the invention is presented for purposes of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms, structures or techniques disclosed. Modifications and variations to those forms, structures and techniques are possible without departing from the scope or spirit of the above disclosure and the following claims. Alternative embodiments will become apparent to those skilled in the art to which the present invention pertains without departing from its spirit and scope.

What is claimed is:

1. A bone fixation assembly for treating a fracture of a bone site, the assembly comprising:

a bone plate having an interior surface configured to contact bone and an exterior surface, the bone plate comprising:

a head portion configured to conform to a metaphysis of the bone, the head portion having one or more polyaxial openings, and

a shaft portion that extends from the head portion and that is generally elongated and configured to conform to a diaphysis of the bone, the shaft portion defining a

first slot and having one or more polyaxial openings, the first slot having parallel side walls;

wherein the one or more polyaxial openings each comprises an inner surface having a plurality of fins protruding from the inner surface.

2. The assembly of claim **1**, wherein the head portion is approximately delta-shaped.

3. The assembly of claim **1**, wherein the first slot is elongated along a length of the shaft.

4. The assembly of claim **1**, wherein the head portion includes three or more polyaxial openings arranged along a direction substantially transverse to a length of the shaft.

5. The assembly of claim **1**, further comprising one or more fasteners for engaging the one or more polyaxial openings, wherein the plurality of fins are deflectable relative to a head of the one or more fasteners when the one or more fasteners is inserted into the one or more polyaxial openings such that the one or more fasteners may be inserted and retained at any one of a plurality of angles relative to the one or more polyaxial openings.

6. The assembly of claim **5**, wherein the plurality of fins comprise a concave upper surface portion.

7. The assembly of claim **1**, wherein the exterior surface is convex.

8. The assembly of claim **1**, wherein the interior surface is concave.

9. The assembly of claim **1**, wherein the interior surface comprises one or more undercuts that traverse across the interior surface.

10. The assembly of claim **1**, wherein the bone plate further comprises an edge comprising at least one scallop.

11. The assembly of claim **1**, wherein the first slot is at least partially threaded, is non-threaded, or comprises an inner surface and a plurality of fins protruding from at least a portion of the inner surface.

12. The assembly of claim **1**, wherein the first slot is configured to accept cortex, compression, osteopenic, or locking screws.

13. The assembly of claim **1**, wherein the bone plate comprises a thickness of approximately 2 mm or less.

14. The assembly of claim **1**, wherein the head portion defines a second slot, the second slot having parallel side walls.

15. The assembly of claim **14**, wherein the second slot is elongated along a direction substantially perpendicular to a length of the shaft.

16. The assembly of claim **4**, wherein a central axis of at least one of the three or more polyaxial openings in the head portion is oriented orthogonally relative to the interior or the exterior surface of the bone plate, and wherein a central axis of at least another one of the three or more polyaxial openings in the head portion is oriented non-orthogonally relative to the interior or the exterior surface of the bone plate.

17. The assembly of claim **1**, wherein an axis of at least one of the one or more polyaxial openings in the shaft portion is oriented non-orthogonally relative to the interior surface of the bone plate.

18. The assembly of claim **1**, wherein the plurality of fins protruding from the inner surface of each of the one or more polyaxial openings have bases that intersect the inner surface, the intersection between the bases and the inner surface defining a single plane.

19. A low profile bone plate having an interior surface configured to contact bone and having an exterior surface, the bone plate comprising:

a head portion that is approximately delta-shaped, the head portion defining a plurality of polyaxial openings; and

a shaft portion that extends from the head portion and that is generally elongated, the shaft portion defining a plurality of polyaxial openings along a length of the shaft and defining a first slot, the first slot having parallel side walls,

wherein the one or more polyaxial openings each comprises an inner surface having a plurality of fins protruding from the inner surface and deflectable relative to a head of a fastener such that the fastener may be inserted and retained at any one of a plurality of angles relative to the one or more polyaxial openings, at least one of the one or more polyaxial openings comprising a concave upper surface portion.

20. The low profile bone plate of claim **19**, wherein each of the one or more polyaxial openings includes five fins.

21. The low profile bone plate of claim **19**, wherein at least one of the head portion or the shaft portion defines one or more provisional pin openings.

22. The low profile bone plate of claim **19**, wherein the plurality of fins protruding from the inner surface of each of the one or more polyaxial openings have bases that intersect the inner surface, the intersection between the bases and the inner surface defining a single plane.

23. The low profile bone plate of claim **19**, wherein the head portion includes three or more polyaxial openings arranged along a direction substantially transverse to the length of the shaft.

24. The low profile bone plate of claim **23**, wherein a central axis of at least one of the three or more polyaxial openings in the head portion is oriented orthogonally relative to the interior or the exterior surface of the bone plate, and wherein a central axis of at least another one of the three or more polyaxial openings in the head portion is oriented non-orthogonally relative to the interior or the exterior surface of the bone plate.

* * * * *